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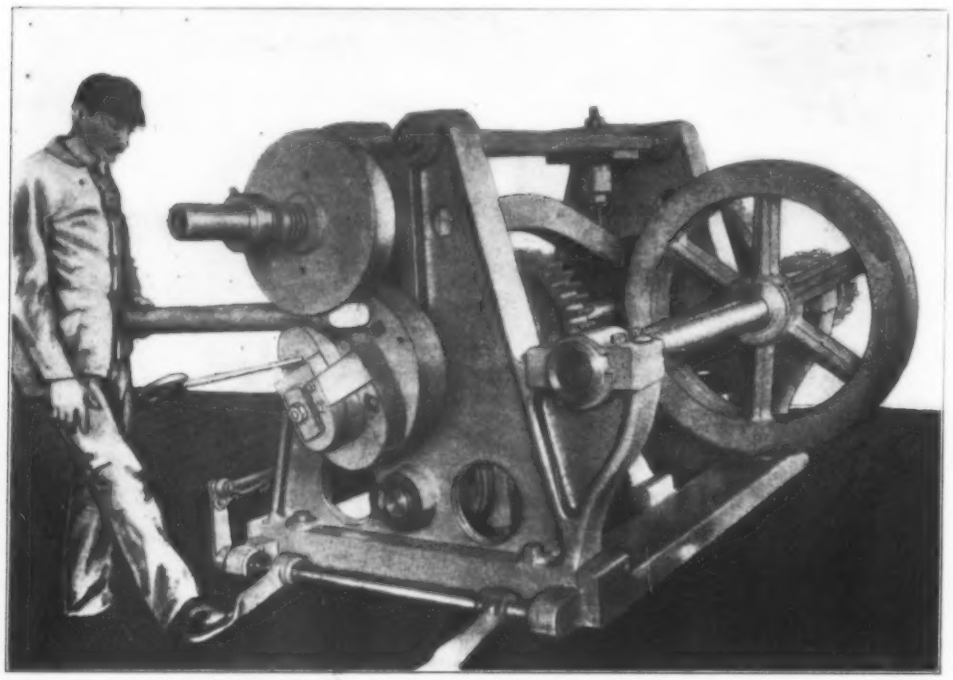
COMPLETED CHAINS; SHOWING METHOD OF HANDLING WITH HOOKS.

SIDE WELDING THE LINK.

THE MANUFACTURE OF FIFTY-TON ANCHOR CHAINS AT LEBANON, PENNA.

MAKING FIFTY-TON ANCHOR CHAINS.

WHAT are claimed to be the largest chains ever made in this country for securing a ship's anchors have been manufactured at the Lebanon Chain Works, of Lebanon, Pa., for the Newhall Chain Forge and Iron Company. They are intended for the steamships being constructed at the plant of the Great Northern Steamship Company, and to bend and join the links special machinery was designed by Eli Attwood, general manager of the works. They were made in four sections or "shots," each comprising 990 feet, so that the total length of the combined chains is nearly 4000 feet. Two will be supplied each ship—one for the starboard and one for the port anchor, but for convenience in handling and construction each chain is subdivided into shots of 90 or 180 feet joined by swivel shackles.



MANUFACTURE OF FIFTY-TON ANCHOR CHAINS.—MACHINE FOR BENDING THE LINK.

The material employed was the highest grade of chain iron. It was drawn out in bars 3 7-16 inches thick for the shackles and 3 3-16 inches for the links. In manufacturing the links the bars were cut or sheared into the requisite lengths, then heated in a special furnace. The bending machine, which is operated by steam power, holds what might be called a model or die of steel of the same shape and size as the opening in the center of the link. The bar while white hot is drawn into shape by the jaws of the bender, enough space being left between the ends to insert the two links connecting with it. After the process the ends are "side welded" by hand in the smith shop. As each link ranges between 19 and 20 inches in length, the lengths cut for bars are each nearly four feet in dimensions.

To hold the weight of the various sections during the welding and shackling processes, also to stow the complete chain, a series of metal blocks and tackles were employed to which large hooks were bolted. The chains connected with the blocks are operated by trolleys sliding along a track fastened to the frame of the shop roof.

The portion of the completed chain was tested by apparatus installed at the Lebanon Works, which is said to be the largest chain-testing machine in this country, having a capacity of 600,000 pounds. At a strain of 510,000 pounds the jaw of the holding shackle of the machine was broken, but none of the links were affected. At the second test the breaking strain was placed at 549,000 pounds when the jaw of the machine feeding the oil to the tester was fractured. The chain itself, however, was unaffected. These figures are 55,000 pounds above Lloyds' requirements for such anchor chains.

A further illustration of the great size of the chains can be given when it is stated that each link averages not less than 165 pounds weight, an average of about 100 pounds to the running foot, making the total weight of each anchor section nearly 50 tons. The chains, of course, will be handled in connection with their respective anchors by steam power, either communicated to large winches or to special stationary engines.

The inquiring man is tempted to ask: Why is it that wire rope is not used instead of chain? It is true that wire rope is very much cheaper than chain; but still its use is attended with grave difficulties.

In hauling in a chain over the wildcat, the links fit in accurately and drop into the holes prepared for them. On the other hand, it would be necessary to wind a wire rope around a drum. Furthermore, a wire rope could not be lowered out of the way like a chain. When the wire rope is wound around a drum, the strands of wire naturally sink into one another and thus give rise to much trouble in running out.

In dropping an anchor with a chain it is always possible to tell how many fathoms have been paid out by the passing of the connecting shackles over the wheel. If wire rope could have been used, it would have taken the place of chain long ago.

Aluminium tubing used in the sciences is made so fine that 1000 feet of it weighs but a single pound.

THE EDUCATION OF THE ELECTRICAL ENGINEER.*

By H. W. BUCK.

ELECTRICAL engineering is probably the youngest of all the professions, for it has hardly been recognized as a regular profession for more than fifteen years past. As a result, the men who have reached prominence in it to-day have attained their positions from widely differing courses of preliminary training; many of them are men who started life in other lines of work and afterward turned to electrical pursuits on account of the sudden growth and importance of the business. In consequence of this, all methods of preliminary education are represented and their relative values can be estimated.

The argument runs largely between two classes of men, one represented by the so-called "practical man" and the other by the theoretical electrician; the graduate of the machine shop and the graduate of the university. Both of these types have attained success, but the correct answer to the argument will probably be found in a proper combination of the two types. In the past some of the most successful electrical engineers have belonged distinctly to the class of practical men with little theoretical training, but the conditions have changed. In the early days of the profession, there was little theory or predetermination of results and work was carried on largely by guesswork or by cut and dry approximations. At the present time, however, such a state of development has been reached that exactness of result is essential to success and work based upon exact theory becomes imperative.

In a stationary condition of an art a man with practical experience only may become very familiar with all the existing types of apparatus and, knowing their various applications, may qualify, to an extent, as an engineer. But the extraordinarily rapid growth of the electrical arts places electrical engineering apart from all the other engineering branches, for new discoveries and theories make radical changes from year to year in the construction and operation of electrical machinery. The engineer whose education is based only upon practical experience cannot keep up with the progress and change resulting from it, and falls behind; whereas, the man with knowledge of the theory, and a mind trained by the theoretical studies and scientific reasoning, easily grasps the theory of the change and readjusts his mind to the new without difficulty or delay. Many instances can be cited of men who have been prominent as electrical engineers, who have been dropped out of place in the course of the rapid progress which has been made, on account of a lack of theoretical foundation in their knowledge. Those who have retained their positions throughout the growth of the art have done so by persistent study along theoretical lines.

In its present state electrical engineering is the most scientific of all engineering professions. A man must be to a great extent a physicist, a chemist and a mathematician, as well as be familiar with machinery and its design, in order to be a worker in the broadest field. Many of the problems connected with other branches of engineering can be solved by common sense and by one's sense of proportion as guided by experience and by the eye. But most of the problems in electricity are invisible, so to speak, and can be understood only through their expression in the form of symbols.

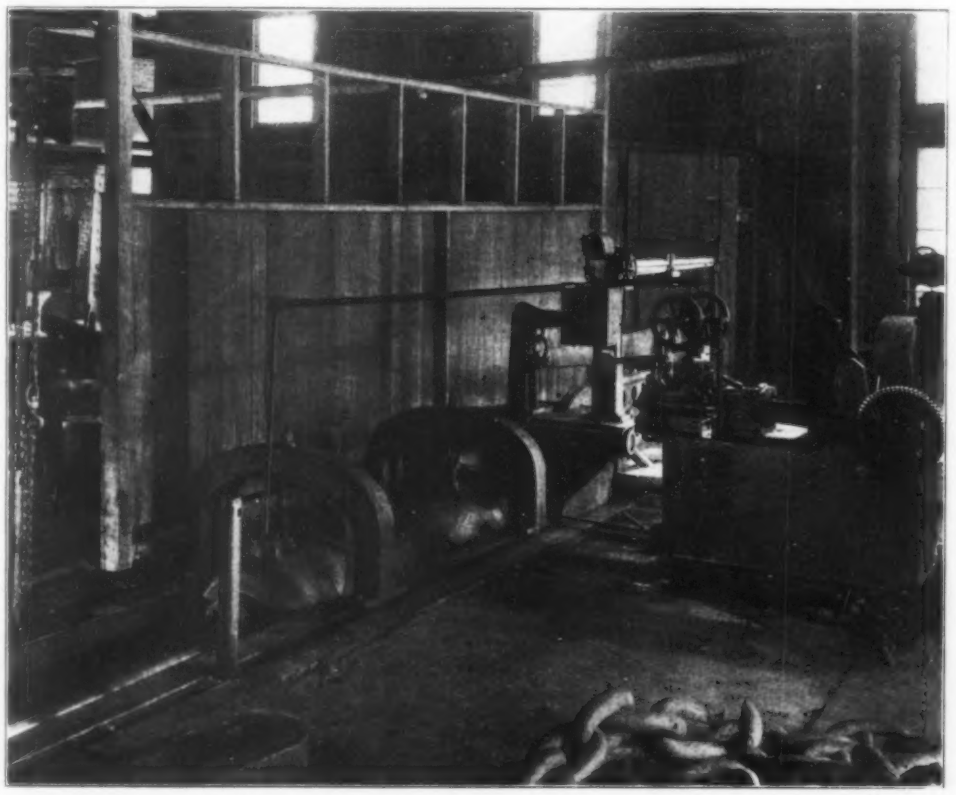
Probably no one will dispute to-day that the preliminary education of an electrical engineer demands a special training in those theoretical branches, mathematics, physics, chemistry and mechanics, sufficient to train his mind into accurate methods of thought and reasoning and to supply him with the actual technical information which he will need in the practice of his profession. But theory alone is not all. The human mind is such that it works with difficulty in pure theory without a series of mental pictures to fix and co-ordinate the ideas, and the study of theory is likely to make little lasting impression unless the physical meaning of the theory is brought out by constant association with actual apparatus which demonstrates the application of the physical law.

The best course of training for an electrical engineer would seem to be a broad course of education in general subjects at the preparatory school before entering college, with practical work, if possible, along lines of simple mechanics, such as carpentry, in order to train the mind into a sense of proportion and the relations of parts, which is the basis of all engineering.

Next a college course with general subjects the first year, and afterward, for the remaining years of the course, those general and theoretical subjects which have a direct bearing upon the practice of the electrical profession, such as mathematics, mechanics, physics, chemistry, theoretical electricity and magnetism and thermodynamics. This should be supplemented by actual daily practical work with machinery operating by the principles covered by the theory studied and demonstrating all the phenomena incident to the theory.

After graduation an apprentice course should be pursued in some large electrical manufacturing establishment where the commercial relations of the knowledge acquired in college can be clearly set forth.

* A paper presented at the Nineteenth Annual Convention of the American Institute of Electrical Engineers.



MANUFACTURE OF FIFTY-TON ANCHOR CHAINS.—HYDRAULIC CHAIN-TESTING MACHINERY.

large machines can be operated which are not available at a college and experience in the installation of large plants can be obtained, and experience gained in the designing departments where all kinds of commercial apparatus are laid out.

After a few years of this training, specialization may begin along the lines selected for the life work but preferably not before. A man makes a mistake to consider himself a qualified electrical engineer after he has been graduated from college, for he is not one. His mind has been trained into a condition where he can readily absorb the principles of the electrical profession, but that is all, and the subsequent apprentice training is as important as the college course, in order to acquire the broad view-point from which to make the correct start in the direction in which a man is best fitted. It perhaps means a smaller income the year after graduation from college, but it means much more at the end of five years.

But theory and practice are not the only elements necessary for the successful engineer. There are many qualities required in common with other professions; executive ability, business knowledge, presence of mind and ability to handle men, nerve and resourcefulness in handling machinery in times of emergency, are all necessary to the successful engineer. These elements cannot be acquired in the study of theory and practice alone, and many men who have stood high in their college courses have failed afterward in the practice of their profession because of a lack of those qualities.

The study of chemistry becomes more and more important as the profession advances, for the branch of electro-chemistry is rapidly developing and is likely to become one of the largest fields in the application of electrical science.

Added almost above all comes a training in the English language. No man who cannot express himself clearly and concisely in writing or in conversation can hope to attain a prominent position in his profession.

The education of an electrical engineer, however, must never be considered as completed. The art advances so rapidly that constant study is necessary, even to keep up with the progress of the times. But an electrical engineer should be willing to do more than this. He should study to keep ahead of progress and do his share toward the instruction of others.

American Coal in Switzerland.—Under date of May 31, 1902, the Aargauische Nachrichten, of Aarau, publishes the following article:

American coal will in the near future take the place of the German and English coal in Switzerland. Switzerland hitherto has been almost wholly dependent on Germany for her coal. During the last year, the German mining companies formed a combine and raised the price 2.50 francs (48 cents) a ton. The Swiss manufacturers had to accept these conditions. An English firm profited by the situation and shipped coal up the Rhine to northern Switzerland. As the cost of the English coal was 1.50 francs (28.9 cents) per ton less than the German coal, considerable orders went to England; but these orders were badly executed.

In the meantime, the American consuls in Switzerland sent reports to the United States upon the state of affairs, and a United States concern promptly seized the opportunity and offered coal at a cheaper price than either the English or the Germans. American agents appeared on the spot and solicited orders. In the French ports of Havre and Rouen, ground was bought and storehouses were erected. Agreements have been entered into with the French and Swiss railway companies to secure cheaper freight rates for the transport of coal through France. In the meantime, orders for American coal have increased largely, as Swiss manufacturers availed themselves gladly of the lower offers.

Thus, the American company has succeeded in gaining a prominent position in the Swiss coal market. Its first large shipment will arrive in Switzerland in a short time.—Henry H. Morgan, Consul at Aarau.

COMPARATIVE ACCELERATION TESTS WITH STEAM LOCOMOTIVE AND ELECTRIC MOTOR CARS.*

By B. J. ARNOLD and W. B. POTTER.

IN connection with the preparation of a report on the use of electricity for the propulsion of trains of the New York Central Railroad in the tunnel entrance and terminals in New York city, an invitation was extended by the General Electric Company to Mr. W. J. Wilgus, chief engineer of the railroad company, to use its experimental track (Fig. 1), and apparatus at Schenectady, and a series of tests were accordingly carried out under the direction of the authors of this paper. The tests were principally for the purpose of determining the comparison between steam and electric traction on short-haul suburban passenger service. Owing to the short curves in the connecting tracks, the General Electric Company's track could not be used for the steam locomotive tests. The steam tests were, therefore, made on the New York Central main line tracks west of Schenectady.

The steam locomotive shown in Fig. 2 was built from the specifications of Mr. A. M. Waite, superintendent of Motive Power and Rolling Stock of the New York Central, by the Schenectady Locomotive Works. It was designed specially for the rapid acceleration work required in suburban service, being provided with large grate area and heating surface and a very large proportion of weight on its driving wheels.

The two electric motor cars were similar in form, 54 feet over all, each weighing about 35 tons, including the electrical equipment, which consisted of four General Electric 55 motors and type M control. All axles being equipped with motors, the two cars together gave approximately the same weight upon the drivers as the steam locomotive. The acceleration was, therefore, directly comparable for trains of equal net weight and to secure this comparison the same trail cars arranged in the same order were used in both the steam and electric tests.

In the steam runs the draw-bar pull, speed and time were recorded by an Illinois Central dynamometer car, and the same car was used with the electric motor cars to determine the relation between current input and draw-bar pull. The dynamometer car had to be returned before the electric runs were completed, but not before a large number of readings were taken, from which curves were plotted showing the relation between amperes and draw-bar pull with different weights of train behind the motor cars. The draw-bar pull thus determined has been plotted on the attached electric motor car curves, which were taken subsequent to the return of the Illinois Central car.

The order of the tests, both steam and electric, was as follows:

A train of six cars, including five standard passenger coaches loaned by the New York Central Railroad, and the dynamometer car, was started and run over a mile of track, acceleration being made as rapidly as possible. These same runs were repeated, dropping off one car at a time, until only the dynamometer car remained. Automatic records were kept of the draw-bar pull, speed, time, distance and the strength and direction of the wind. The condition of rail and temperature were also noted. The same runs were repeated, using the two motor cars in place of the steam locomotive, the dynamometer car being used in some of the runs and a box car loaded to equal weight in subsequent runs. In the electric runs, additional records were kept of voltage, ampere and wattmeter readings. The wattmeter was not carried on the car, but was placed stationary at the point of feeding the third rail, thus avoiding any inaccuracy due to jarring. The voltage leads of the wattmeter were connected to the extreme end of the third rail and track, thus receiving at all times the exact voltage at the train, so that the energy delivered to the motor cars represented the net input and did not include losses in the feeder system.

The cars used in this test and the weights are given below:

New York Central locomotive	No. 1407	..	214,000 lbs.
General Electric motor car	No. 4	..	73,000 lbs.
General Electric motor car	No. 5	..	70,000 lbs.
Illinois Central dynamometer car	No. 17	..	45,640 lbs.
New York Central coach	No. 1885	..	48,200 lbs.
New York Central coach	No. 545	..	60,250 lbs.
New York Central coach	No. 1709	..	53,700 lbs.
New York Central coach	No. 508	..	51,450 lbs.
New York Central locomotive	No. 1407	..	214,000 lbs.

During the tests many runs were made, but for the illustration of this paper, representative and average runs only are given.

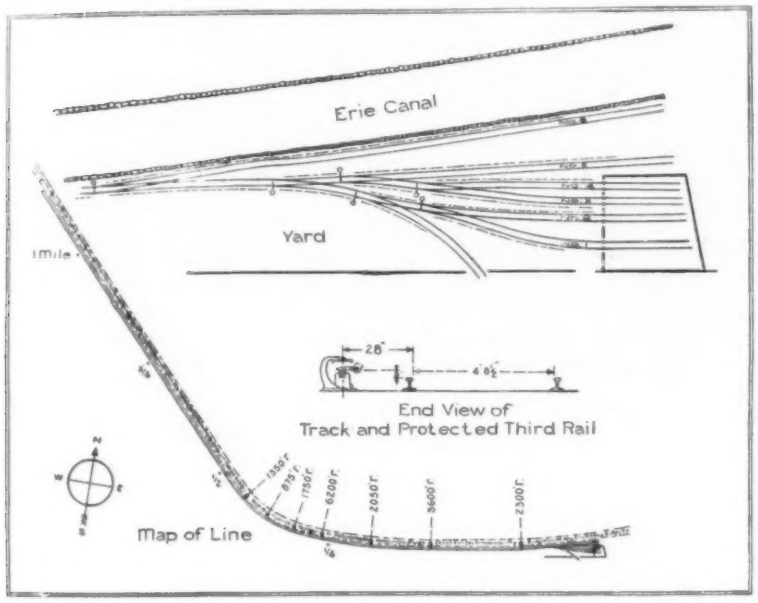
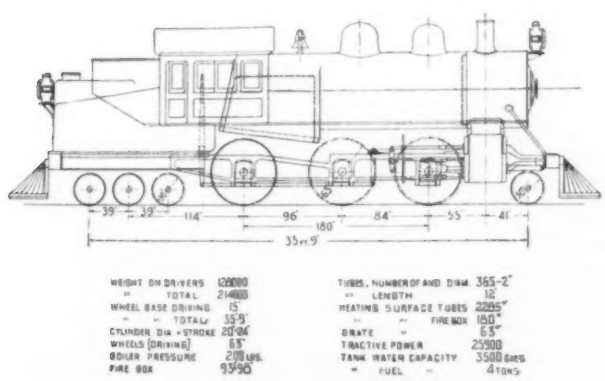


FIG. 1.—Map of General Electric Railroad.



WEIGHT ON DRIVERS	128000	TUBES, NUMBER OF AND DIAM.	365-2"
" TOTAL	214000	" LENGTH	12'
WHEEL BASE DRIVING	15'	HEATING SURFACE TUBES	2295 sq. ft.
" " TOTAL	35'9"	" " FIRE BOX	150 "
CYLINDER DIA. & STROKE	20"-24"	GRATE "	63"
WHEELS (DRIVING)	63"	TRACTIVE POWER	25900
BOILER PRESSURE	200 LBS.	TANK WATER CAPACITY	3500 GALS.
FIRE BOX	93"-90"	" FUEL "	4 TONS

NEW YORK CENTRAL LOCOMOTIVE No. 1407

FIG. 2.—Outline of Steam Locomotive No. 1407.

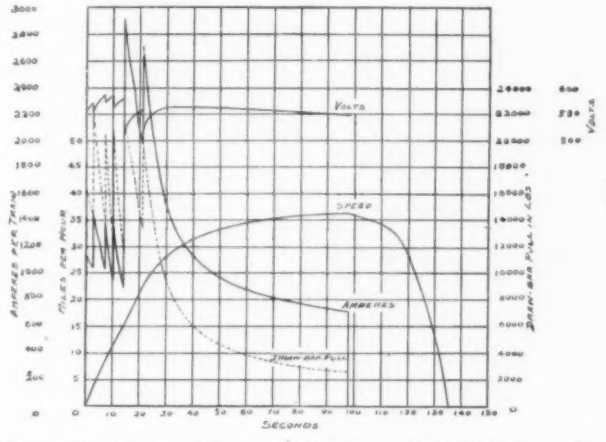


FIG. 3.—Electric Run No. 1. 6 Trail Cars—Weight 157 tons. Including Motor Cars 228.5 Tons. Power on 4,170 ft. Distance Run 5,380 ft. Watt hours per ton mile 79.4.

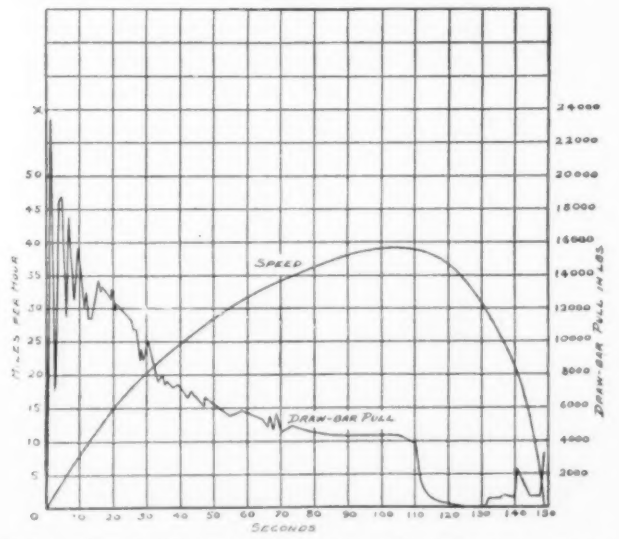


FIG. 4.—Steam Run No. 2. 6 Trail Cars—Weight 157 tons. Including Locomotive 264 tons. Power on 4,035 ft. Distance Run 6,150 ft.

* A paper presented at the 19th Annual Convention of the American Institute of Electrical Engineers, Great Barrington, Mass., June 19, 1902.

ELECTRIC MOTOR CARS NOS. 4 AND 5.

The electric runs were made upon the General Electric experimental track against a head wind of 15 m.p.h. The rail was dry, the temperature 8 deg. C., and the grade practically level. In the middle of the run there was a curve having a minimum radius of 875 min., equivalent to about 6½ deg. curve, the effect of which may be assumed as approximately equivalent to the 1 per cent up grade of the steam runs.

No. of run.	Character of load.	Weight of load, tons.	Total weight of train, tons.	Maximum speed.	Average speed.	Watt hours per ton mile.	
						From volt amperes.	From watt-meter.
1	6 Trailers.	157.0	228.5	36.4	27.2	75.9	79.4
3	5 "	130.0	201.5	37.9	28.6	78.4	82.0
5	4 "	104.0	175.5	39.1	29.8	84.3	86.9
7	3 "	77.0	141.5	41.0	30.6	81.7	93.4
9	2 "	47.0	118.5	42.8	32.0	98.5	99.4
11	1 "	23.0	94.5	44.7	33.1	115.0	114.0
13	No "		71.5	46.7	34.6	132.3	129.0

NEW YORK CENTRAL STEAM LOCOMOTIVE NO. 1407.

All steam locomotive runs were made upon the New York Central main line track west of Schenectady against an up grade of 1 per cent and a head wind of 15 m.p.h. The temperature was 4 deg. C. and the rail wet with a very light falling snow.

No. of run.	Character of load.	Weight of load, tons	Total weight of train, tons	Maximum speed m.p.h.	Average speed m.p.h.
2	6 Trailers.	157.0	264.0	30.0	28.2
4	5 "	130.0	237.0	41.3	28.4
6	4 "	104.0	211.0	40.9	27.4
8	3 "	77.0	184.0	45.7	27.3
10	2 "	47.0	154.0	48.0	30.1
12	1 "	23.0	130.0	50.9	33.0

Although this locomotive was especially built for suburban or acceleration work, and was provided with a large fire box, giving it facilities for rapid steaming, the pressure dropped from 200 pounds to less than 185 pounds during the first part of acceleration. In starting, the throttle was opened wide and steam used full stroke, the engine being hooked up as acceleration proceeded. Curves showing detail of these runs are given in Figs. 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 and 15.

While the electric runs had the advantage of drier rails than the steam runs, the driving wheels were not slipped in either instance. Although the steam locomotive was able to give a maximum tractive effort at starting equal to that obtained electrically, this high tractive effort was not maintained, but immediately fell off with increased speed, even with the most expert handling.

As the acceleration curves produced by the steam locomotive and electric motor cars have different shapes, and as in the two tests there was about the same weight upon the drivers, it is interesting to note how well this driver weight was utilized. This is shown by the following tables giving the speed reached in ten, twenty and thirty seconds with equal trailing load for both electric and steam trains.

MILES PER HOUR ATTAINED IN 10 SECONDS.

No. of trailers.....	1	2	3	4	5	6
Motor cars Nos. 4 and 5..	22.5	20.7	17.3	14.4	12.6	11.
Locomotive No. 1407.....	14.	13.	12.5	12.	10.	9.1

MILES PER HOUR ATTAINED IN 20 SECONDS.

No. of trailers.....	1	2	3	4	5	6
Motor cars Nos. 4 and 5..	34.	32.3	29.4	27.4	24.5	21.2
Locomotive No. 1407.....	25.	21.2	21.5	19.5	18.	16.3

MILES PER HOUR ATTAINED IN 30 SECONDS.

No. of trailers.....	1	2	3	4	5	6
Motor cars Nos. 4 and 5..	38.2	36.4	34.2	32.	30.3	28.1
Locomotive No. 1407	31.7	26.2	27.	24.7	23.2	20.8

An inspection of the above tables brings out clearly

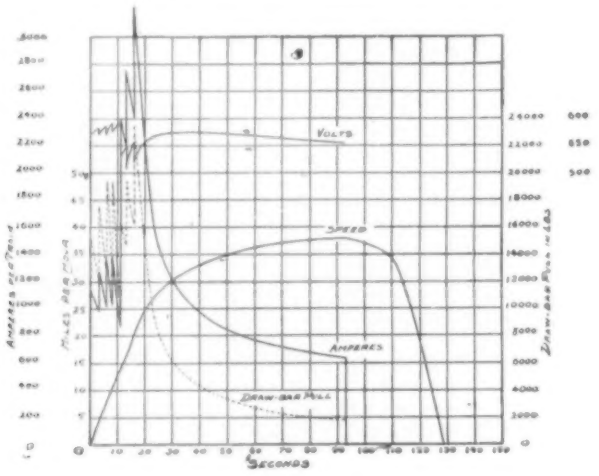


FIG. 5.—Electric Run No. 3. 5 Trail Cars—Weight 130 tons. Including Motor Cars 201.5 Tons. Power on 4,170 ft. Distance Run 5,380 ft. Watt hours per ton mile 82.

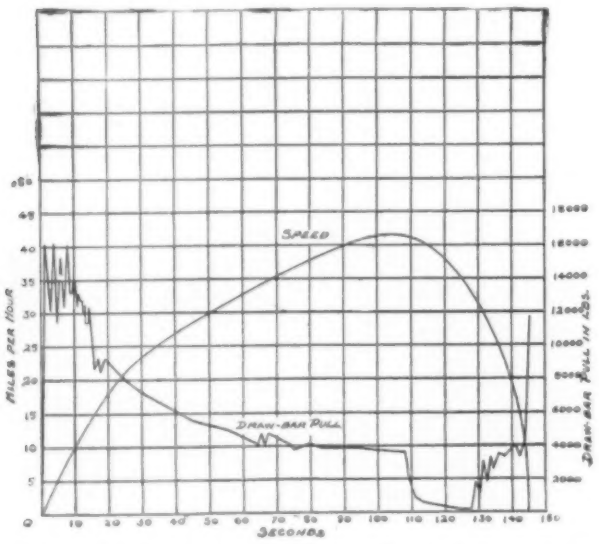


FIG. 6.—Steam Run No. 4. 5 Trail Cars—Weight 130 tons. Including Locomotive 237 tons. Power on 4,270 ft. Distance Run 6,050 ft.

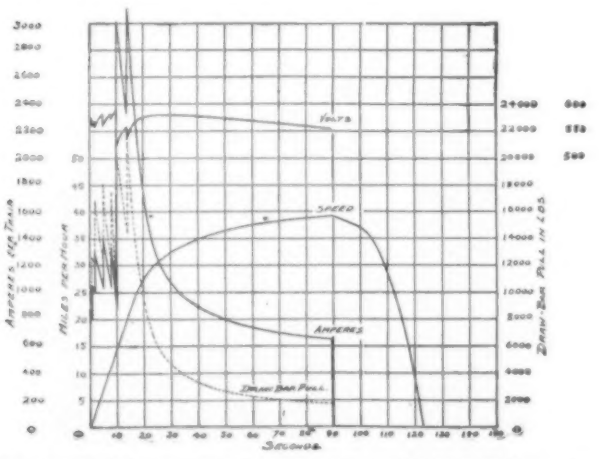


FIG. 7.—Electric Run No. 5. 4 Trail Cars—Weight 104 tons. Including Motor Cars 175.5 Tons. Power on 4,135 ft. Distance Run 5,380 ft. Watt hours per ton mile 86.9.

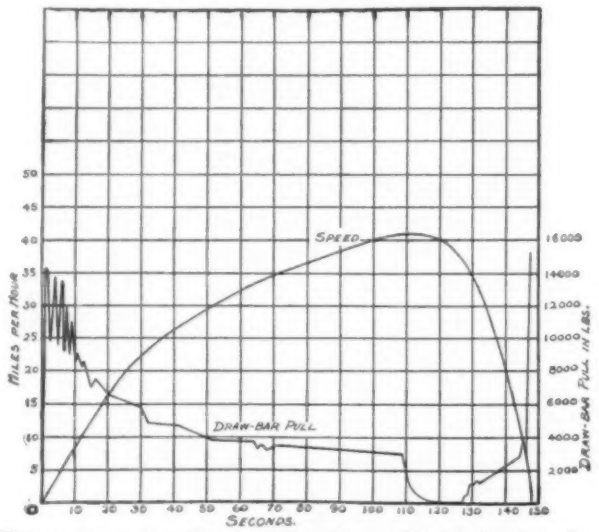


FIG. 8.—Steam Run No. 6. 4 Trail Cars—Weight 104 tons. Including Locomotive 211 tons. Power on 4,490 ft. Distance Run 5,943 ft.

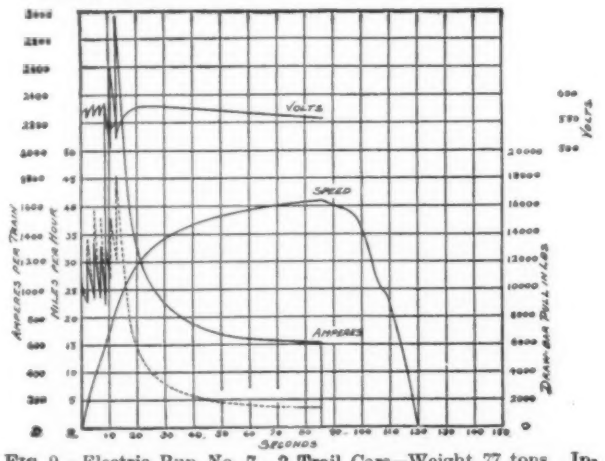


FIG. 9.—Electric Run No. 7. 3 Trail Cars—Weight 77 tons. Including Motor Cars 148.5 Tons. Power on 1,470 ft. Distance Run 5,370 ft. Watt hours per ton mile 93.4.

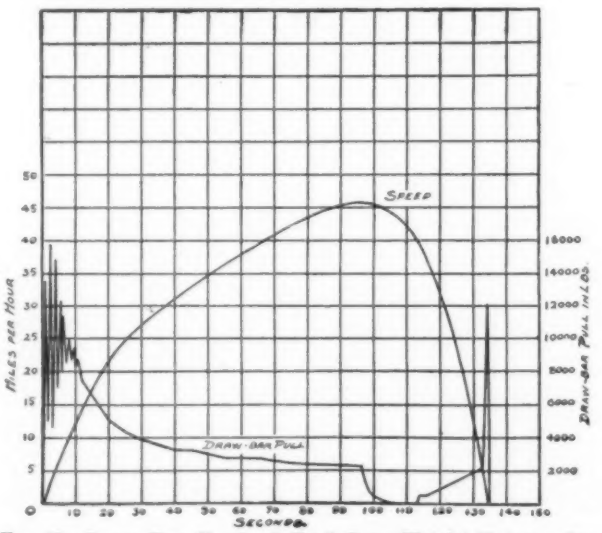


FIG. 10.—Steam Run No. 8. 3 Trail Cars—Weight 77 tons. Including Locomotive 184 tons. Power on 4,520 ft. Distance Run 5,930 ft.

the fact that the electric motors during acceleration can more effectively utilize the weight upon their drivers than a steam locomotive. As rapid acceleration is especially important when stops are a mile or so apart, the electric motor has an advantage in being able to cover the same distance in the same time with less energy expended and at less maximum speed than with the steam locomotive, owing to its being able to maintain its maximum accelerating rate for a longer period.

The average speed given in both steam and electric tables is the average speed of the train while it is in motion and does not include time of any stop at the end of the run. Starting from rest, the power was kept full on to the three-quarter mile post, where the power was shut off and the brakes applied in such a manner as to bring the train to rest as near the mile post as practicable. In the tests the steam train ran from 5 to 15 per cent over a mile before the train was brought to rest and the electric trains from 2 to 4 per cent, but even with the longer distance the average speed of the steam runs only approaches that attained in the electric runs made over a short distance. A comparison of the two sets of runs on the basis of average speed is, therefore, not quite fair to the electric motor car, as its average speed would have been considerably higher if the length of the run had been the same as that made with the steam locomotive.

An inspection of the tables will show, however, that even with the shorter distance run, the electric motor cars were able to make higher average speeds than the steam locomotive over its longer distance, and these higher average speeds were obtained also with a lesser maximum speed.

The maximum speed of a train making a given run in a given time serves as an indication of its energy consumption. A train, therefore, which is so handled as to make a given run in a given time, with lowest maximum speed, will consume less energy for the run. The electric runs tabulated will show a lower maximum speed and a higher average speed than those runs made with the steam locomotive, and the energy consumption of the electric runs should, therefore, be less for the same service performed than with the steam locomotive.

The motors of an electrically equipped train may be placed upon the trucks of ordinary passenger coaches, each carrying its full complement of passengers, and thus lessen the gross weight by elimination of the locomotive. The true measure of comparison between steam and electrically propelled trains should be the energy per seat mile rather than per ton mile, as the latter value is based upon the total train weight and includes a considerable proportion of dead weight embodied in locomotive and tender. The weight of the electric motors is much less than the weight of a steam locomotive capable of performing the same service, as the latter, in addition to its tender, must be heavy enough upon its drivers to provide a draw-bar pull sufficient to accelerate the train.

As an illustration, the following table has been prepared from these tests showing the number of cars in the train, the number of passengers carried (each car seating 64 people) and the energy, which for convenience we have given in watt hours, required per passenger for both steam and electric runs.

NET ENERGY PER PASSENGER CARRIED.

Number of Cars.	Number of Passengers.	Watt Hours per Passenger Steam.	Watt Hours per Passenger Electricity.
6	384	43.9	29.7
5	320	52.2	32.1
4	256	57.5	33.5
3	192	77.4	37.5
2	128	103.0	45.2
1	64	187.8	45.2

This table is based upon the actual net energy delivered to the wheels of the train and does not include the losses inherent to any system of operation. The results tabulated may, therefore, be considered as fundamental, and typical of the two systems of operation—the steam locomotive and the electric motor car.

The following table gives the efficiencies for the seven electric runs, the efficiency being the ratio be-

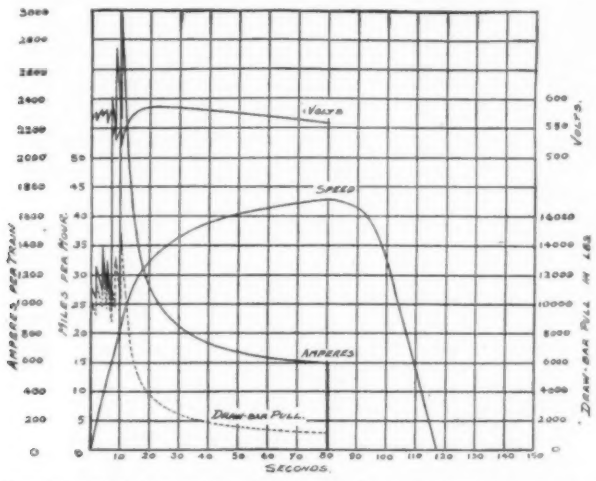


FIG. 11.—Electric Run No. 9. 2 Trail Cars—Weight 47 tons. Including Motor Cars 118.5 tons. Power on 4,100 ft. Distance Run 5,490 ft. Watt hours per ton mile 99.4.

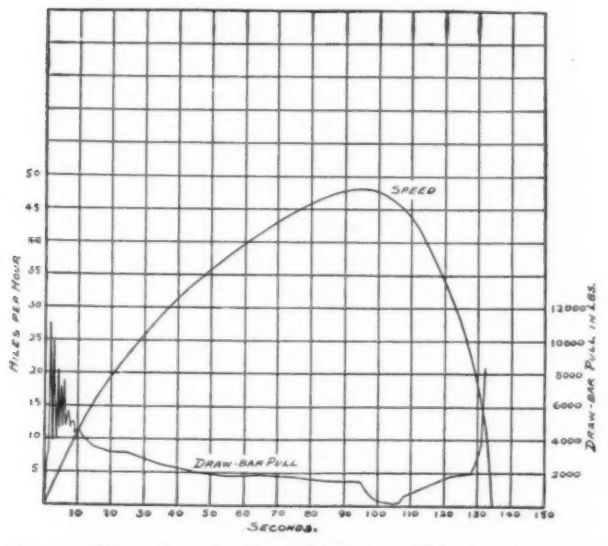


FIG. 12.—Steam Run No. 10.—2 Trail Cars—Weight 47 tons. Including Locomotive 154 tons. Power on 4,455 ft. Distance Run 5,927 ft.

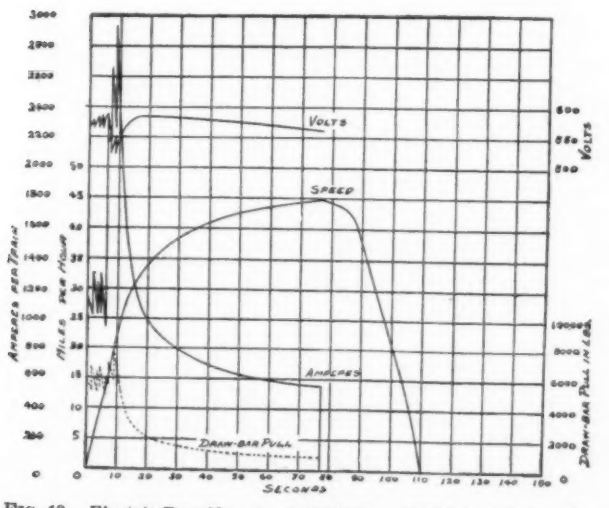


FIG. 13.—Electric Run No. 11. 1 Trail Car—Weight 23 tons. Including Motor Cars 94.5 tons. Power on 4,060 ft. Distance Run 5,350 ft. Watt hours per ton mile 114.

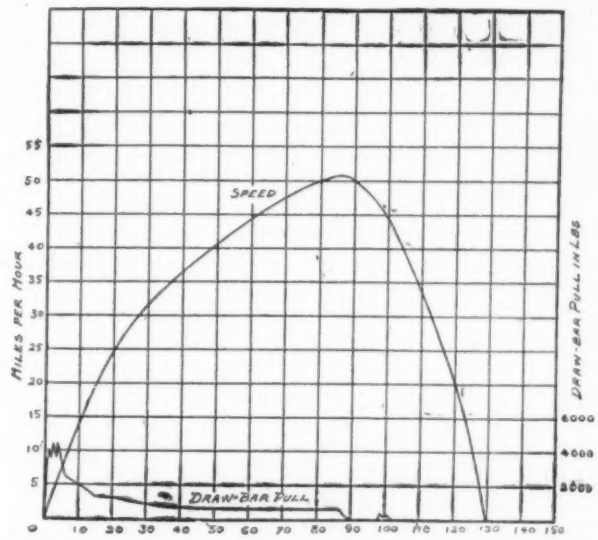


FIG. 14.—Steam Run No. 12. 1 Trail Car—Weight 23 tons. Including Locomotive 130 tons. Power on 4,460 ft. Distance Run 6,260 ft.

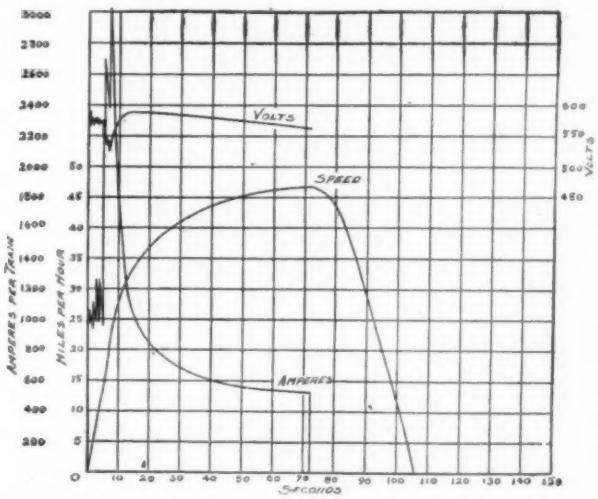


FIG. 15.—Electric Run No. 13. No Trailers. Motor Cars 71.5 tons. Power on 4,080 ft. Distance Run 5,360 ft. Watt hours per ton mile 129.

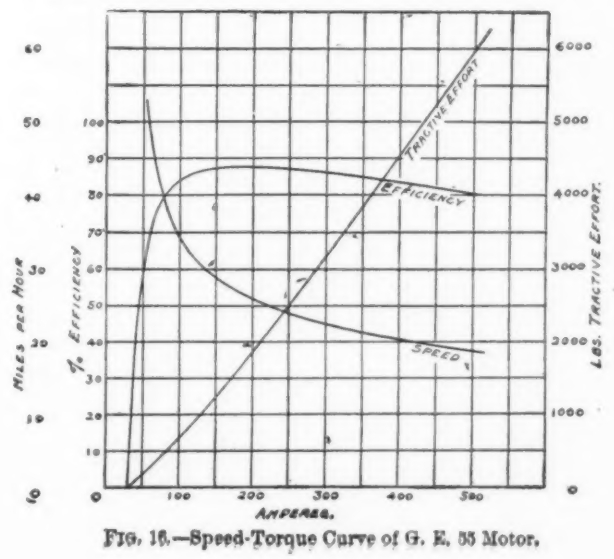


FIG. 16.—Speed-Torque Curve of G. E. 55 Motor.

tween net energy output to the wheels and total volt ampere input:

EFFICIENCY OF ELECTRIC RUNS.

Trailers.	Average m. p. h.	Watt hours per ton mile. Output.	Input.	Efficiency of run.
6	27.2	59.1	79.8	74. per cent
5	28.6	61.0	82.0	74.3 per cent
4	29.8	63.8	84.9	75.3 per cent
3	30.6	68.0	90.2	75.3 per cent
2	32.	69.6	99.6	69.9 per cent
1	33.1	75.3	112.8	66.7 per cent
0	34.6	79.8	130.0	61.5 per cent

An accurate comparison of the relative efficiency or coal consumption of steam and electric power for similar service would require an extensive series of tests with indicator and dynamometer on the performance of the steam locomotive.

As a matter of interest we have secured an approximate comparison from a single test by weighing the coal and water taken by steam locomotive No. 1407 for a period of 24 hours, covering four trips between North White Plains and Grand Central Station, a distance of 24.75 miles, on the Harlem Division of the New York Central Railroad. The trips occupied about 4 hours, the yard movements about 1 hour, and the locomotive was idle for 19 hours.

Following is a detailed record of the service covering the 24 hours:

NORTH WHITE PLAINS TO GRAND CENTRAL STATION.

Time.	Number of Cars.	Number of Stops.	Total Weight.	Weight of Cars.	Effective. h. p. h.
63.5 min.	3	21	204 tons	97 tons	129
Lay-over.....6 hours.					

GRAND CENTRAL STATION TO NORTH WHITE PLAINS.

Time.	Number of Cars.	Number of Stops.	Total Weight.	Weight of Cars.	Effective. h. p. h.
66.25 min.	5	17	278 tons	171 tons	255
Lay-over.....12 hours.					

NORTH WHITE PLAINS TO GRAND CENTRAL STATION.

Time.	Number of Cars.	Number of Stops.	Total Weight.	Weight of Cars.	Effective. h. p. h.
60.3 min.	7	13	387 tons	280 tons	231
Lay-over.....¾ hour.					

GRAND CENTRAL STATION TO NORTH WHITE PLAINS.

Time.	Number of Cars.	Number of Stops.	Total Weight.	Weight of Cars.	Effective. h. p. h.
59.75 min.	4	20	256 tons	149 tons	246
Lay-over.....1¼ hours.					
Total effective h.p. hours, hauling coaches..... 861					
Coal consumed ..... 13,412 pounds					
Coal per effective h.p. hour..... 15.6 pounds					

The effective h.p.h. given above is the energy required for movement of the cars only, exclusive of the locomotive, and was determined from the draw-bar pull taken by dynamometer car in previous tests over the same route.

The coal consumption covers all coal burned during the period of 24 hours, not only for movement of cars but also movement in the yard and banking of fires during lay-overs.

The effective h.p.h. to move the cars serves as the basis of comparison with electric service, the coal consumed by the locomotive for whatever purpose being properly chargeable to the net work done by the locomotive during the period.

The efficiency of an electrical system, as an average under variable load, may reasonably be assumed as follows:

Engine	90 per cent	Efficiency
Alternator	92 per cent	"
High potential transmission....	98 per cent	"
Transformers	97 per cent	"
Converters	92 per cent	"
Third rail	95 per cent	"

Motors, including control, 75 per cent efficiency, 51.33 per cent.

This percentage of effective horse power output of motors to i.h.p. of engine will vary somewhat, depending on the load factor. As an even figure we will assume an efficiency of 50 per cent.

Coal consumption per indicated h.p.h. from actual records of electric power stations, is in some cases less than 2 pounds, the average being about 2½ pounds. At the latter figure, the coal per effective h.p.h. output of electric motors would be 5 pounds. Assuming the head end air resistance as 10 per cent and as the electrical equipment would increase the weight of the cars about 20 per cent, the actual comparison of coal consumption would be approximately in the ratio of 6.6 for electric and 15.6 for steam.

Assuming that coal for a power station can be purchased for 80 per cent of the cost per ton of that used in the locomotives and that the cost of coal for electrical power is about one-third of the total cost, including maintenance and interest on investment, it is probable that the actual gross cost of electrical power would closely approximate the coal consumption of a steam locomotive in this class of service, the maintenance of the electrical equipment and attendance required being, however, considerably in favor of the electric power.

We wish to express our thanks to Mr. E. C. Schmidt, Professor of Railway and Mechanical Engineering, University of Illinois, for his able management of the dynamometer car, assisted by Messrs. J. F. Snodgrass and R. W. Lohmann; also to Messrs. A. H. Armstrong and E. F. Gould of the General Electric Company for their careful supervision and calculations of the electric test.

THE ELECTRIC PROBLEM OF RAILWAYS.*

By J. SWINBURNE.

THE electric problem may be divided into four parts —generating, transmitting from the station at high pressure to the railway or to the part of it in question, distributing the power to the passing trains and utilizing it.

* Abstract of paper read before the Manchester section of the Institution of Electrical Engineers.

SHORT RAILWAYS: SYSTEMS OF MOTORS.

Beginning at the train end of the subject, as the system adopted there dominates the rest, the first question is: What motors should be employed? In the tube railway the trains are seldom running at full speed; they are stopping or starting or waiting at a station. The important consideration from the motor point of view is, then, acceleration and braking. There is a limit of permissible acceleration which depends on the comfort of the passengers. This may be taken at about 0.7 m. (2.3 feet) per second, and ought itself to start up gradually. The retardation may be a little more rapid, as the passengers are generally sitting down, whereas on starting there are generally many who have not yet found their places.

On constant potential circuits there must be considerable loss of energy each time the train starts, for the motors at rest give no back pressure, and the back pressure increases with the speed until full speed is reached. If the motors are so wound that the back pressure is proportional to the speed, as in the case of shunt motors, for example, or series motors with the current controlled so as to be constant, and if the acceleration is constant with reference to time, the starting has an efficiency of 0.5 m. By arranging two sets of motors so that they can be coupled in parallel or series, 0.166 m. extra is obtainable, making an efficiency of 0.66 m. The odd 0.33 m. is wasted on resistances. In the case of a tube railway this is a very serious loss, as it obviously means not only extra coal consumption, but larger plant throughout.

Dealing first with starting only, we may assume the stations are 0.75 km. (825 yards) apart, as this is a convenient average distance for a tube railway. With such a small distance the question of acceleration is all-important. It is difficult to know what acceleration is really permissible. To people sitting down the acceleration is not important, but at starting there are always people standing up, finding their seats, and at busy times of the day many have to stand large portions of the way. A sudden change from uniform speed to an acceleration of 1 m. would probably upset everyone who was standing and had nothing to hold on to. But if the acceleration itself begins gradually, there is no limit to it, owing to discomfort of passengers, within anything that the conditions of the railway will permit. If a second or two were devoted to the growth of the acceleration, there could be little objection to any acceleration up to say, 1 m. The gradual growth of acceleration can be secured, in the case of series motors, for instance, by not switching on the full current instantly, but letting it grow to its full value in a second or two. It may be remarked, in parenthesis, that there is great room for saving time at the stations. Even on the Central London, for example, there is unnecessary delay as the passengers get in and come out at the same doors. It would be better for one end of the car to be the entrance and the other the exit—people arranging themselves between the stations.

The acceleration is of enormous importance on the type of railway under discussion. If the trains accelerate up to half distance, and then retard to the next station, the time occupied varies inversely as the root of the rate of acceleration. The energy per passenger, assuming the trains equally full, varies as the acceleration, and as the square of the maximum speed between the stations.

The next question is the maximum speed between stations. In the usual systems there is waste of power in the starting resistances, and the further the speed is from that at which the motors take their normal current without starting resistances the greater the waste. With a given acceleration, therefore, the lower the maximum speed the less the waste of energy. But this is, to some extent, balanced by the longer time.

If a table is calculated out, or curves made showing the relations between the times, distances and accelerations, the great importance of acceleration will be readily seen. In urban railways the train resistance is only some 7 per cent of the highest speed, and less of the lower speeds. Practically all the energy becomes kinetic except what is wasted in resistances and gear friction.

As the energy varies as the square of the highest speed, there is considerable saving in not running up to the maximum velocity. For instance, if acceleration is only carried on for quarter the distance between stations, with an acceleration of 0.5 m. (1.65 feet) it only makes a difference of four seconds between stations, while it halves the energy. At an acceleration of 1 m. (3.3 feet per second) there is a saving of three seconds. For the purposes of comparison we may take an acceleration of 0.7 m. (2.3 feet).

If the ordinary series motors are used, and are coupled in series at first, and then in parallel, they would be probably designed for a full speed of 60 km. (37.5 miles) an hour; that is to say, to take their full current with no resistance in series at 60 km. an hour. Being series motors they would go on accelerating, and would get to the halfway point in less than 34.4 seconds. The acceleration would still go on, so that the second half of the curve would not be quite a repetition of the first. The result would be nearly as good as if the motor had been designed for a maximum speed of 82 km. (51 miles) an hour, as far as time goes, and it would be smaller, and there would be less waste of energy by resistances on each start; 82 km. an hour is the maximum speed if the train accelerated at 0.7 m. for half the distance to the next station.

The next system to consider is the shunt motor. If the shunt motor is controlled so as to have a constant armature current during acceleration, it behaves like a series machine; but in practice the controller goes in steps, and the current may vary considerably; this gives rise to sparking. In addition, as the field wire is smaller the magnets must be larger, and room is always important in railway work. The shunt machine arrangement is less efficient than the series, because it must be wound for the highest speed. If this speed is reached before halfway, the train will continue from that point at constant speed with a reduced current, and there may be commutator sparking. With best modern practice it is probable this sparking can be reduced so as to be of no importance. Either the shunt or series machine can be arranged to give back some of the energy by electric braking; but it would have the same want of efficiency due to resistances as during acceleration.

The great rival of the direct-current series motor is the polyphase, which corresponds very nearly with the shunt-wound direct-current motor, except that there is no chance of trouble from commutators. Only one of two motors may take the line pressure, the second being coupled in concatenation up to half speed. The first can then be wound for high pressures, and the rest of the circuits may have pressures convenient for handling. This prevents the use of the second machine in parallel with the first above half speed. This is not so serious a loss as might be thought. If it is worked out the time taken between stations is increased very little by the idleness of the second motor about half speed. The chief drawback of the polyphase motor is its limit of speed.

The single-phase alternating-current motor is not at present available, unless it runs at constant speed.

Constant-pressure supply is not a good solution of the problem of dealing with various speeds. Let us, therefore, consider the constant current. At present we are only considering the motors, or rather the train equipment.

The series motors would be wound for the torque to give the acceleration employed, say, 0.7 m. There is no loss by external resistance, and the back pressure increases with the speed till halfway is reached. The connections are then reversed, and the motors become dynamos, giving forward pressure in the mains, and breaking at the same acceleration as before, except that it is negative. As there is no loss by external resistance, and as in the case we have taken for comparison the power spent on acceleration is very large in proportion with the power spent on train resistances, the series system returns a large percentage to the mains. Compared with the constant-pressure system there is thus a great gain of energy.

Shunt motors will give approximately the same results on constant potential. The armatures or fields need not be reversed for braking. The shunt motor has no real advantage in this case, and it has the disadvantage of possible commutator troubles and of large variations of current. The resistances are altered by steps, and not continuously, and this causes a larger variation of current in a shunt motor, as the field resistance is not in series with the armatures, and there are no corresponding variations of field tending to check the variations of current.

The three-phase system is analogous to the shunt direct current. It has the advantage of absence of commutator. Compared with the series-wound direct current, this is of little importance, as there is no trouble from sparking. The motors have an idle current, however. This is really a question that concerns the distribution, mainly; but it also concerns the motors as it lessens the brake power. The idle current depends on the air-gap, and on the frequency. If the second motor has a power factor of 0.9, as the first motor will have to carry the idle current for the second, its power factor will be about 0.72. The first motor will thus have to be rather larger, but the power taken and returned by braking in concatenation will not be materially less than that in the case of the direct-current motors. The power returned by concatenated motors braking is saddled with such a bad load factor that it is probably not worth having.

The three-phase system can also be worked on a constant-current circuit; but as the frequency must vary with the speed, each train must have its own engine, unless some special arrangement is made in the distributing system. One special arrangement will be brought forward in discussing the question of distribution.

DISTRIBUTION ON SHORT LINES.

Turning now to the question of distribution, the first point is to settle the pressure. The present practice of 500 volts is really due to the street tramway; there is no particular reason why it should be adopted for railways. It may be said that 1000 volts is dangerous, and 2000 volts to 5000 volts means practically certain death if a contact is made. Other things being equal, alternating pressures of the same voltmeter value are more dangerous than direct, and in making comparisons as to danger it might be well to allow the same maximum pressure in each case. This paper is meant rather to deal with the future, and it seems highly probable that as soon as there is a strong commercial necessity for dangerous pressures they will be allowed. If high pressures are to be used they should be made as safe as possible, of course, by the best safety devices. Still, the danger is a drawback, and whether there are safety devices or not, a high pressure line should be considered as dangerous, and people fully warned, so that if they court danger it is at their own risk.

In dealing with a short railway, 1000 volts has been taken as a convenient pressure, and there seems to be an impression that there is something about alternating and three-phase machines which gives them some sort of monopoly of high pressure. The reverse is largely the case as regards danger, and as regards insulation.

As to the distribution in the various cases discussed, the current in the direct-current constant-potential system is half for the first part of the acceleration, so there is some economy there compared with the series system. Roughly, the current for half the time of starting is only 720 amps. It is 1440 amps. for the other half, corresponding to an effective current of 1140 amps. The three-phase takes 720 amps. right through, but there is an idle current to be considered. During the first half the power factor was taken as 0.72, so the current is 1000 amps., and during the second half it is 800 amps., the factor being 0.9. This gives an effective current of, say, 890 amps. The series system, however, demands the whole 1440 amps., not only during acceleration, but during running, and during stoppages at stations. The question of how far series pays depends largely on the distance from the generating and sub-stations. If the distance is great, the constant potential direct-current can be

modified by only using one motor during the second part of the acceleration. As already explained, this does not increase the time between stations much, and it reduces the current to 720 amps.

If there is a sub-station every second station, and a current density of something like 150 amps. per square centimeter is adopted, the loss in conductors is not serious. In a tube railway the trains are very frequent, so a low-current density pays. In long-distance work the problem is very different. In the sub-stations there is little difference. For the direct-current constant potential the distribution is generally by extra high pressure three-phase, with transformers and rotaries. For direct constant current the extra high pressure is also direct-current. There is no work of this sort in this country at present. Unless there is some special reason for distributing power in this way, other systems are better, or are, at any rate, more familiar. There is no difficulty in generating extra high pressure direct current, and it is done in Switzerland, where Messrs. Thury have made a specialty of it. There is little doubt the insulation is cheaper, and there are no capacity or self-induction troubles, no idle currents, and no triple switches and measuring instruments.

The three-phase system avoids the rotaries, which is an advantage. On the other hand, three wires are necessary, and this involves an extra contact. The rails are not well adapted for alternating currents. The low-power factor increases the leads, the transformers and the generators.

The constant-current three-phase system demands a dynamotor for each section, which is a drawback. The primary is extra high pressure direct constant current, and the secondary is constant three-phase current. For short tube lines this system seems to have no advantage over the direct constant current.

In the station the constant-current system, whether direct or three-phase, has the peculiarity that the engines always work at constant torque, but at varying speeds. The result is, that for a given daily output the coal consumption is less, as the engines always work at the best cut-off. The wear and tear is also probably somewhat less.

LONG RAILWAYS: COMPARISON OF SYSTEMS.

Instead of dealing next with an intermediate or suburban line, we will go to the other extreme, and consider a main line. The problem is entirely different. Acceleration is comparatively unimportant, and the energy is chiefly used for overcoming the train resistances. The capital cost in mains and sub-stations is greater in proportion to the traffic, as large proportions are frequently idle. It is therefore important to run light trains frequently. The present system tends toward heavy trains run comparatively seldom, and in goods traffic this practice is carried as far as possible.

It is therefore very difficult to decide on anything like a simple case of main-line traffic. In the first place high speed is advisable, more especially between such centers as London and Manchester, and Manchester and Newcastle. Such cases as intercommunication between Manchester and Liverpool, or between the various busy Yorkshire centers, belong to the intermediate class. It must be remembered that it is comparatively easy to devise systems, not only of block signaling, but of automatic control for electric railways, as the power is not generated on the train, and can therefore be shut off from the outside. We may therefore have lighter trains running at high speeds, and running frequently. As an example we may therefore adhere to the 100-ton train. We may, having regard to the future demands, consider a speed of 125 km. (75 miles) an hour. It is difficult to make the case definite enough for clear comparison between the possible systems. We may therefore first run over the peculiarities of each and see how they affect the problem.

The constant-pressure system with direct currents has the drawback of waste of energy during acceleration; but if the trains go long journeys that is no longer important. The chief difficulty is the limit of pressure possible. There seems to be an impression that direct-current motors can only be made for low pressures. As a matter of fact they are mostly made for low pressures; but that is merely because there is no demand for high-pressure machines, except for arc lighting; and there is little series arc lighting now. As a direct-current machine can be easily made to give from 1000 volts to 2000 volts for arc lighting, there can be no difficulty in making large railway motors for such pressures. An arc machine is the most difficult to make for high pressures, because the rate of increase of the pressure relatively to the current has to be negative; so that the field is comparatively weak, and the diameter of commutation varies. If a 10-amp. machine can be made from 1000 volts to 3000 volts, there can be no difficulty in making a similar machine for about 1000 amps.

It may be safe to take 2000 volts as suitable for main-line work. The limit of 2000-volt transmission is not so small as may be thought. Our ideas of transmission distances are largely gathered from incandescent lamp practice. In that case there is an accumulation of small drops; in the high pressure mains the transformers, the meters and the house leads, and at the end is a lamp which is sensitive to minute variations. In the case of a main-line train, we may lose quite a large percentage of the pressure in the mains. At a current density of 150 amps. per square centimeter the loss of pressure is 27.2 volts per kilometer. If we care to spend 500 volts on the mains between two points of supply, the points can be 37 km. apart, if there is no loss in the return leads. It is unlikely that a main line could be run satisfactorily on the three-wire system, so instead of 37 km. it would be better to allow little more than half that distance, say, 20 km. This means a sub-station every 40 km.

The direct constant-pressure system has the great disadvantage of only suiting fixed speeds. Thus, if the motors are wound for 120 km. at 2000 volts, they will not work efficiently at any lower speed. The train, therefore, must run at 120 km. an hour or waste power. This trouble can be largely overcome by making the motors large, so as to give a better acceleration. Two motors in series will then run the train considerably above 60 km. an hour. The two motors in parallel will also run the train above 120 km., so as to give some margin for making up time—a most important consideration.

The series constant direct-current system has no longer the same advantages as in the case of the tube. The acceleration is no longer of vital consequence. With a given maximum pressure, and a given distance between sub-stations, the loss in the leads is greater, for the leads always carry the maximum current. The series system has some compensations, however. It does not follow that because the motors are taken as limited to 2000 volts that the line may not work at, say, 10,000 volts. The difficulty here is that the motor must be insulated from the bogie, so as to stand high pressures. With 10,000 volts and a maximum loss of 25 per cent, or 2500 volts, we would allow a distance of 92 km. between sub-stations. This would generally mean that there would be no sub-stations, only generating stations, and they could be placed, as a rule, near large towns, so that they could supply their customers. The series system has the advantage of allowing any speed at high efficiency. The ability to return energy in braking need not be considered, as in long-distance work it is impossible to allow large enough motors to give good acceleration. It would therefore pay better to brake by mechanical means than to waste time slowing down in order to get back a little energy.

The three-phase constant-potential system has some of the advantages of the constant-pressure direct-current. It falls behind in some points. There are three wires instead of two, and the motors cannot exceed their normal speed, however late a train may be. On the other hand, the system has the advantage that it can be worked for long distances, and frequent sub-stations can be put down, as they contain only still machinery. The distances apart of the generating stations are thus only limited by the economy of transmission at high pressure.

The series three-phase system gives the same advantages as regards distance between central stations, but it is at a disadvantage compared with constant-pressure three-phase system, as its advantage in acceleration is more than compensated by the need of having sub-stations with moving machinery for each block, with a dynamotor for each train that may be fed by the sub-station.

CONSTANT-PRESSURE DIRECT.

For the sake of making some sort of comparison, we may take the generating stations at 80 km. (50 miles) apart. This is certainly far enough to prevent the need of an excessive number of power stations. At the busiest time of the day, which is what has to be provided for, we may take a half-hour service each way as sufficient for through traffic. This will demand stations of the order of 6000 kw. to 8000 kw., which is smaller than one likes, but still large enough to be fairly economical.

Taking first the direct-current constant-pressure system at 2000 volts, the simplest arrangement would be to have two sub-stations for each power station. A train would then never be more than 13.3 km. from a sub-station. The trains want, say, 330 amps. at full speed. A question at once comes up, whether it pays to have greater torque for accelerating. The simplest way of doing this is to have a double allowance of motors. At starting two motors are in series, and at half speed the extra motor is thrown out. As the motors will probably drive at least four axles, there will be, say, four motors of 1000 volts each, and they will all be in series on starting, only two being in series above half speed. The starting motors may be comparatively small, as they only run for a minute or two at a time, and are cooling for the rest of the journey.

The conductors have to carry 330 amps., which, at 150 amps. per square centimeter means 2.2 cm^2. Strictly speaking, however, the lead should not be run at a constant density, for the current is in the parts near the sub-stations longer. We may take the lead at 1.5 $cm.^2$ average area for each track. This would mean 1.5 cm. × 2.92 cm. = 1.338 tons of copper per kilometer for the main. It is a question how much should be allowed for the return, as it would naturally be worked on the three-wire system; but sometimes one side might be full and the other empty, so it might be as well to allow, say, 14 tons of copper for the return, of which 7 tons would be charged to each side, making 24 tons.

Each transformer sub-station must supply one-third of the distance between the main stations; that is to say, 27 km. Each ought to be able to supply 1.5 times the power for a single train; that is to say, 2000 volts and, say, 1000 amps. This would be effected by one large rotary with another as spare, or by two 1000-kw. rotaries with one spare. Then the transformer sub-stations would have 27 km. of high-pressure cable at, say, 8000 volts and 250 amps.

For the constant potential system at 2000 volts we may reckon for each distance of 80 km.:

Distributing mains (copper only)		25,000
9000-kw. static transformers	11,250	11,250
6000-kw. rotary transformers	18,000	18,000
Extra high-pressure mains	80,000	53,000
Total		94,750

The figures only refer to the parts that vary with the system adopted, and therefore do not give the cost of fitting out the railway electrically. They are also very rough estimates.

CONSTANT CURRENT DIRECT.

The series system has two mains for each line, carrying 330 amps., 1.5 $cm.^2$ in action. This comes to 6 cm. × 8.92 cm. = 5.35 tons per kilometer, or £30,000 per section bare. A large addition would be necessary for insulation for 10,000 volts.

THREE-PHASE.

The three-phase system is the same as the direct-current constant-pressure, except that there are no rotary transformers. In this case it might pay to have more sub-stations, so as to decrease the cost of the copper, as the cost of subdivision of sub-stations would not be serious.

The constant-current three-phase system saves some £10,000 per section in transformers, but costs extra for extra sub-station rotaries.

The result of these estimates is that series costs less per kilometer, but the comparison is by no means on all fours, as the constant-pressure has high-pressure cables completely protected from contact, while the series has 10,000-volt conductors exposed, involving danger and cost of maintenance.

It is, perhaps, hardly necessary to work out a sample of intermediate types, such as between Manchester and Liverpool, because they are equivalent to sections of the through main line. The only difference to be considered is the question of frequent stoppings and startings. A main line runs quick passenger trains, also stopping trains, goods and minerals. At present a slow and a stopping train are synonymous. There is no reason why a train that stops at many stations should run slowly between them, except that a locomotive that is designed for acceleration is not suitable for running fast, though the steam locomotive is better than the electric on constant pressure, because it is not wasteful while accelerating. It is just as important that stopping trains should waste little time as that express trains should be fast; in fact, there is greater reason in many cases, as the worst and most uncomfortable carriages are put on these trains. The most important are the suburban trains carrying large numbers of business men, and stopping at every station. In this case acceleration is of the highest importance, as in the tube railways.

CONCLUSION.

Enough has now been said to show that it is advisable to pause a little before we convert our railways into electric street tramways. It will be a calamity if our railways take up different systems of electric working; if some have 500 volts, others 1000 volts, 2000 volts or 10,000 volts; if some have constant currents, some direct, and some three-phase, while others have constant pressure of each kind.

There is some slight adaptability in electric locomotives. Of course a three-phase motor will not run on a direct current circuit, but a constant-pressure locomotive will, with very little addition, be capable of running on a constant-current circuit; and the locomotives can be built to run on either, if the pressures and currents are right. The locomotives built for 500 volts are not suitable for 2000 volts. If the 500-volt locomotives are for tube railways with large acceleration, they can hardly be run as express locomotives, as their motors will run too fast; otherwise electric locomotives are more adaptable than steam, as they can have several motors, which can be coupled in different ways.

What are most necessary are standard pressures and currents. Each railway would then have, as at present, slow locomotives with great pull for shunting, for goods traffic and for suburban and stopping trains, and fast locomotives with less acceleration but higher speed for through traffic.

CONTEMPORARY ELECTRICAL SCIENCE.*

WIRELESS TELEGRAPHY.—The transmission of wireless signals over distances affected by the curvature of the earth is a phenomenon still awaiting elucidation. E. Lecher supposes that there is some analogy between the way in which the conducting surface of the earth affects the waves and the way in which a wire affects the same waves. As Sommerfeld has shown, a wire placed in the direction of propagation of an electric wave produces peculiar effects. The electric oscillations are always at right angles to the surface of the wire, and a portion of the wave energy penetrates into the surface layers of the wire. It may be supposed that in a somewhat similar manner the waves of wireless telegraphy run along the surface of the earth, and especially of the sea, and a portion of the energy enters the earth's surface. Sea water is, as we know, a "good conductor" as regards waves of the Hertzian type. A crucial experiment would consist in conveying wireless signals between two balloons at the same height, by means of vertical antennæ. Communications should be the easier the smaller their elevation. It would be also interesting to attempt to send signals up a precipice, with horizontal and vertical antennæ respectively. —E. Lecher, Phys. Zeitschr., April 1, 1902.

CATHODE RAYS IN A MAGNETIC FIELD.—The solid tubes of magnetic force traced out by cathode and canal rays under certain conditions (see The Electrician, p. 734) offer considerable theoretical difficulties. H. Pellat continues their study, and attempts to indicate the direction in which an explanation must be sought for. It appears that already in 1890 A. Witz had found that in strong fields the cathode rays follow the lines of magnetic force, but not that they trace out a tube of force. In the present communication Pellat endeavors to disprove the supposition that the electric particles described long spirals about the lines of force which nearly coincide with them. On varying the magnetic field from 140 to 5,000 units, it is observed that the rays at first show the simple Crookes deflection, then straighten out along the axis of the tube, and finally follow the tubes of force. If the spiral theory were correct, the spirals should be seen gradually closing upon the tube of force. The author believes that there is some agent at work which makes the corpuscles run along the lines of force, and that this agent is of the nature of a friction across the lines of force.—H. Pellat, Comptes Rendus, March 24, 1902.

OSCILLATION OF IONS.—Crémieu's failure to produce motion in a charged plate by means of an oscillating magnetic field has led B. Davis to the idea of substituting for the charged plate a body which is capable of carrying an enormously greater charge in proportion to its mass—viz., the ion itself. He produces a "ring discharge" in a tube surrounded by a coil conveying a Tesla discharge. In this arrangement no electrodes are used. What happens is that the ions are set into an oscillatory motion along circular arcs concentric with the coil, the negative electrons exerting a greater effect in the way of collisions and ionization than the positive ions, on account of their superior

* Compiled by E. E. Fournier d'Albe in The Electrician.

speed. The author mounts a set of four vanes on a needle parallel to the axis of the coil. The vanes are convex on one side and concave on the other. It is practically a miniature anemometer, which rotates in the direction of the convex side of the vanes, whatever the direction of the impinging electrons may be. The best effect was obtained at a pressure of 0.64 mm., when the white ring discharge replaced the red ring discharge. Under favorable conditions the anemometer attained 40 revs. per sec. At other pressures the radiometer effect exerted a disturbing influence.—B. Davis, Phys. Zeitschr., April 1, 1902.

RECONSTRUCTION OF THE UNDERGROUND FOUNDATIONS FOR THE PARIS METROPOLITAN RAILWAY.

WE have already studied the different phases of the construction of the Paris Metropolitan Railway, and have seen that the next line to be built is that portion of the great loop extending between Place du Trocadero and Place de l'Italie, and passing through the south of Paris. The work is to be begun immediately, and we shall revert to it in due time. It is well, however, to speak just now of the preparation of the Parisian subsoil of certain regions that the city line is to traverse, and which is particularly interesting in the Fifth, Sixth, Thirteenth, Fourteenth and Fifteenth wards, in which extend vast quarries now abandoned, but which for many centuries afforded material for the construction of houses on the surface. These quarries are arranged in levels that occupy considerable space. In many places, even, these layers of stone are superposed in two stories.

In these quarries there exist a large number of galleries which ramify in a most fantastic manner. The mission of the inspection service of the quarries of the city of Paris is to visit them constantly and fill in or prop them up so as to prevent subsidences that might damage the roadway and surface constructions.

The method employed of old in working the quarries consisted in advancing underground as long as serviceable material was met with. Galleries were driven, and, as the stone was quarried from the sides, pillars were left for the support of the ceiling of these immense chambers and passageways. After the stone had been removed the working gallery was sometimes preserved and the empty spaces were filled in with the excavated earth.

When the ceiling was sufficiently supported there was nothing to be feared, since it was impossible for a cave-in to occur; but, at other places, where the protection was not adequate, the layers of stone fell either into the open space of the galleries or upon the but slightly resistant bed of loose earth, and brought about more or less extensive subsidences. In certain cases these assumed very curious forms called "fontis" (Fig. 1). The earth and stones became disintegrated at a single point and, settling down, left above them a

FIG. 1.—THE OLD QUARRIES OF PARIS: APPEARANCE OF A VAULT FORMED BY A CAVE-IN.

sort of vault that sometimes reached considerable heights—say, 35, 50 and even 55 feet. Such subsidences were subject to constant change. The roof of the vault thus formed gradually disintegrated under different influences and dropped to the bottom, forming a large heap beneath the vault. If care were not taken and the vault not attended to, the result of such progressive wear would be that the street would suddenly open and everything within the proximity of the zone of subsidence would be precipitated to the bottom. To prevent such an accident, the quarry engineers faced the interiors of the vaults with stone and constructed large internal domes, the masonry of which was at some places 3 feet or more in thickness. Such is the material of the subsoil in certain sections that are to be traversed by the Metropolitan. It will be seen that such a support was hardly adequate as regards solidity, and there is no doubt that if important reconstruction work had not been undertaken we should have had to deplore disastrous subsidences very often.

Speaking in a general way it may be said that there are two systems of reconstruction that are alternately employed according to the nature of the quarries over which the line is to pass. When the quarry is well preserved all that is done is to drive a gallery in a line with the axis of the railway and construct transverse sustaining walls to the right and left thereof. As a general thing these walls are 4 feet in width and extend to a mean depth of 13 feet. But this figure is not constant, since the work consists in replacing the old excavated material by pebbles and coarse sand. Now, since no rule was followed in building the underground abutments in former times, it is never exactly known in advance what quantity of masonry is to be employed. Things are so arranged that the arch-buttresses of the future tunnel shall always have a firm and solid mass beneath them. When vacant spaces are met with they are filled in with masonry that extends to the top of the gallery and is constructed as far as possible upon masses of intact stones of the quarry. At the station sites the sustaining walls are made of larger dimensions, and their number is increased in order that there may be a greater resistance to the horizontal thrusts necessarily caused by the ellipticity of the vaults at the stations.

The second process is employed in places where subsidences have occurred. These vary considerably in appearance and form. In certain cases the galleries no longer exist, they having been destroyed by a mass of stone that has fallen and obstructed all the passages. In other places the gallery remains intact, but the sides have sunk and the vein of stone has crumbled away upon the loose earth that has been brought in. In this case the strengthening of the foundations can no longer be effected by the system of walls. As the object of the latter is to replace the earth that has been removed, they can be utilized only where excavations have been made. As the desired result cannot be accomplished by subterranean work, it is necessary to drive wells from the surface until solid earth is reached, and this is often found beneath the level of the quarries. These wells are 4 feet in diameter and are filled with concrete. They form solid buried columns (Fig. 2). They are constructed in a double row 19.69 feet apart, and the axis of which corresponds on each side of the line of the future railway. They are connected in pairs by means of a horizontal flooring of expanded metal in concrete, placed immediately beneath the masonry of the vaults of the tunnel to be constructed. By this construction the latter rests upon an unyielding support completely independent of the arrangement of the old quarries.

The length of the line that is about to be reconstructed by the processes just mentioned is 1.86 mile. This work, although it is in nowise visible, since not a single stone of all the masonry constructed will ever be seen, is exceedingly costly, the contracts let out for the section under consideration reaching as a whole 1,800,000 francs ($360,000).—For the above particulars and the illustrations we are indebted to La Nature.

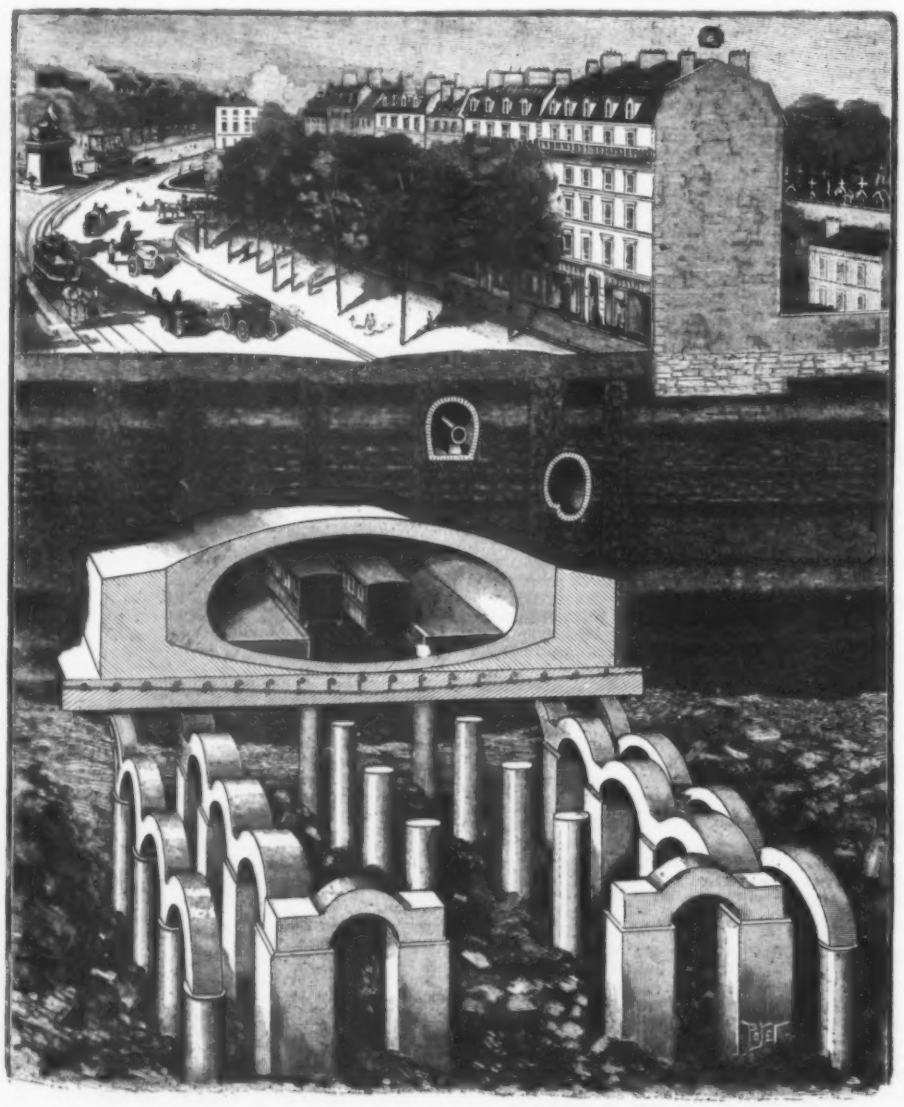


FIG. 2.—THE FOUNDATIONS IN THE SUBSOIL OF PARIS FOR THE METROPOLITAN RAILWAY, AT THE SITE OF ONE OF THE STATIONS.

IMPROVEMENTS IN THE GOLDSCHMIDT PROCESS.

ACCORDING to a report in the Zeitschrift des Vereins Deutscher Ingenieure, the Goldschmidt process for welding rails has been greatly simplified. The funnel-shaped crucible in which the required quantity of thermite is melted is about 16 inches high, 12 inches wide at the top, and from ¾ to 1 inch wide at the bottom, which is perforated. While the reaction is going on, the bottom hole is closed by means of an iron plug, and as soon as the exact moment for discharging arrives, this plug, which is covered with a little fine dry sand to prevent premature melting, is knocked up into the liquid, when it is immediately fused. The crucible is covered with a metallic hood, and its contents are ignited through a hole in the hood. The advantage secured by such an arrangement is that the metal flows into the mold before the slag, whereas in ordinary crucibles the slag always runs off first. The loss of heat by radiation is also much reduced, and the lining exposed to the heat of thermite a few seconds only; that is to say, no longer than is just required for completing the reaction. In welding objects, the surface on which the thermite is poured has to be cleaned first with a file; the abutting ends of the rails or bars require no preliminary treatment. Other applications of this method of obtaining high temperatures are described by its inventor in Stahl und Eisen. He specially refers to its advantages for welding purposes, and mentions that chromium and manganese are now manufactured on a large scale by this process. Huge crucible-like vessels are used, and some hundredweights are produced simultaneously, the whole operation only requiring half an hour from start to finish. The carbon-free chromium is chiefly employed in steel making, while the pure manganese finds application in the manufacture of copper-manganese alloys. Ferrochrome, containing from 40 to 65 per cent of metallic chromium, was the only form in which chromium was available to the steel maker, and, therefore, all such steels are, strictly speaking, not chrome steels, but chrome-carbide steels. The advantages of pure chromium are obvious. In the open-hearth process the chromium is added toward the end of the operation, when the introduction of impurities is most objectionable. The loss by oxidation, which amounts to from 20 to 25 per cent with high grade ferrochrome, is considerably reduced when pure chromium is used.

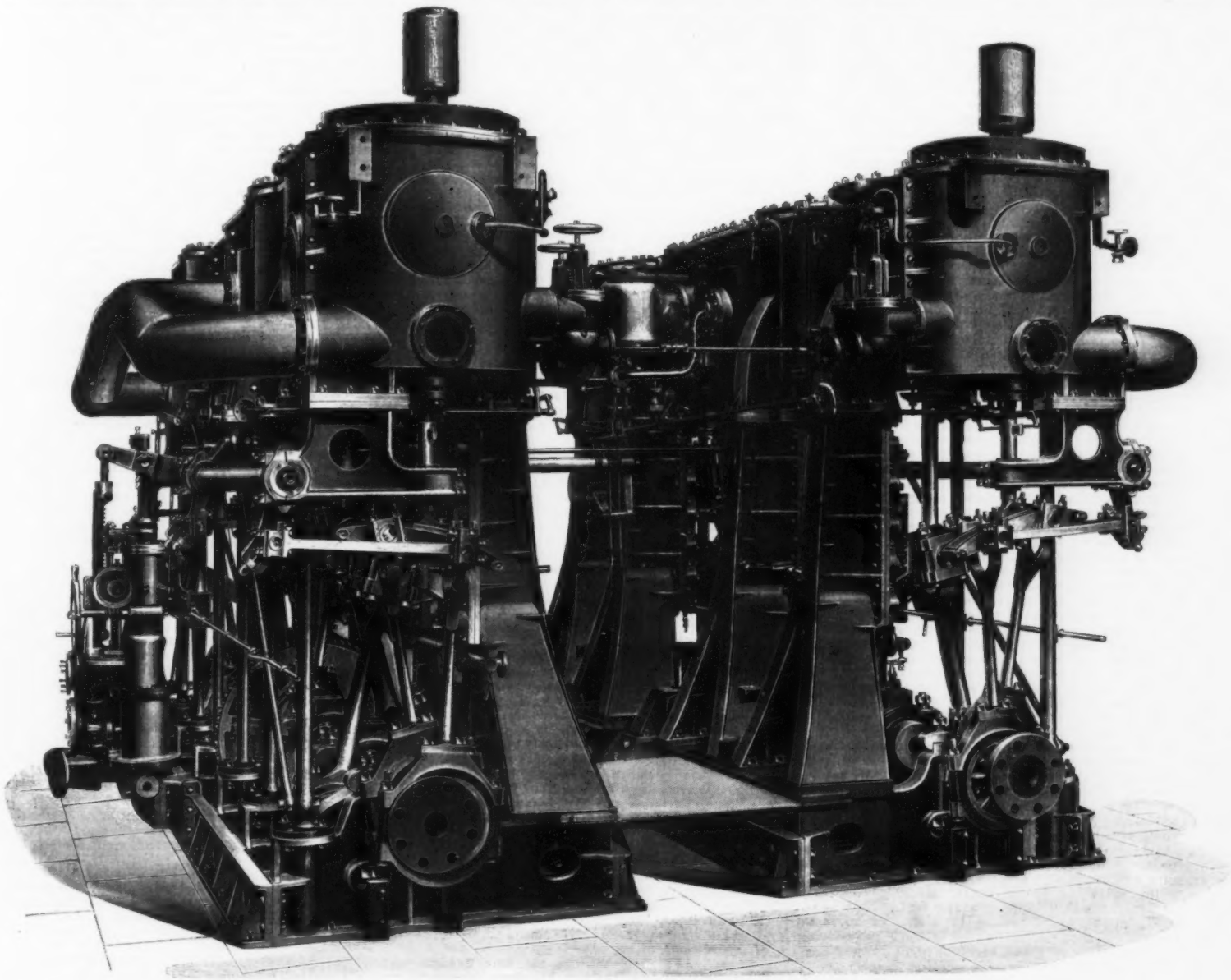
Polish for Mahogany.—Mix one part of old boiled linseed oil with 2 parts of an alcoholic solution of shellac. Agitate each time before using, and apply in small quantities, rubbing vigorously until the polish is attained.—Drug. Circ.

ENGINES OF THE TWIN-SCREW STEAMER "ARUNDEL."

FULFILLING the promise given in our article of February 21, on the "Cross-Channel Passenger Steamship Services," that we should give an illustration, etc., of the main engines of the London, Brighton and South Coast Railway Company's mail steamer "Arundel," employed in the Newhaven-Dieppe service, we have pleasure in now presenting to our readers, in our present issue, a perspective view—looking forward—of the two sets of fine twin-screw engines fitted in that vessel by Denny & Brothers, of Dumbarton, who are also the shipbuilders.

Having in the issue of the Engineer above referred to given a detailed description of the "Arundel's" engines, it need not be repeated here. In reply, however, to the query often put to us, as to why water-tube steam generators are not more frequently fitted by British engineers to such types of vessels as the "Arundel," we may say that the water-tube boiler has been "tried" in several instances in Channel steamers, and has been found "wanting," so much so indeed as to have led to the determination to replace them with the well-tried type of boilers fitted by Messrs. Denny in the "Arundel," these consisting of two double-ended cylindrical boilers, with three corrugated furnaces at each end, worked at a pressure of 160 pounds per square inch, on the closed stokehold system, which are found to give ample steam for the efficient propulsion of the vessel under the most trying conditions of sea and weather met with in the English Channel.

The "Arundel" has, as previously stated, beaten the "record" in the run from Dieppe to Newhaven, she having, on April 20, 1901, left the former port at 1:49 P. M., and arrived at the latter at 4:49 P. M., thus making the time from port to port three hours, or twelve minutes less than had been previously occupied in covering the distance.—Engineer.



ENGINES OF THE TWIN-SCREW STEAMER "ARUNDEL."

HIGH-SPEED ENGINES.*

IT is certain that the question of high-speed engines has not yet been finally and conclusively settled. The engine so called became gradually more popular in England during a period extending over many years; but the fact that America and continental Europe have never shown any marked tendency to follow the English lead in this matter as they have done in so many others has without doubt created, if not a reaction, at least a disposition to reconsider the matter in this country. Few engineers can be skeptical as to the new style of engine permanently holding its own for certain classes of work especially adapted to its particular virtues. There is at present a greater inclination toward impartiality of judgment on this question than there was a few years ago. It will be well if engineers generally take advantage of this disposition to try to determine which are the kinds of work which are best served by the competing classes of engines.

In approaching the subject one is always at once confronted with the question, What is a high-speed engine? Unfortunately, the term is quite legitimately used in two senses entirely distinct from each other. The piston speed of an engine is of paramount importance in many respects; but it would be unfair to say that "engine speed" means necessarily piston speed, while, on the other hand, if the piston speed be high, who could rationally refuse to the engine the title "high-speed"? What is more commonly referred to as "engine speed," however, is its rotational speed, and thus it arises that what in modern parlance we call a high-speed engine nearly always denotes one running at a large number of revolutions per minute.

The air would certainly be cleared for more careful and sober investigation of pros and cons if there ceased to be diffused among purchasers of machinery and half-informed engineers the idea that high piston speed generally, if not invariably, goes along with high rotary speed. That it does not do so is well known to all who take the trouble to examine figures. A very high rotary speed is 600 revolutions per minute, and we never find this associated with a greater stroke than 8 inches, and very rarely with so long a stroke. This gives 800 feet per minute piston speed; but, as with one or two exceptions only, all the engines running successfully at such rotary speeds are single-acting, the real effective piston speed is half the above, or 400 feet per minute. Now, double-acting engines with 5 feet and 4½ feet stroke are run without difficulty at 80 and 90 revolutions per minute, giving 800 feet and 810 feet per minute effective piston speed. Any piston speed over 600 feet per minute, and any rotary speed over 300 revolutions per minute, may be termed high. The easier way to get high piston speed is with long stroke and low rotary velocity; the only way practicable to get high rotary velocity is to use a short stroke, and be content with comparatively low piston speed.

What is the merit of high piston speed? The simple elementary aim is evidently to get as large horse power as possible from an engine of given bulk and cost. With prescribed boiler pressure, piston diameter, ratio of expansion, and exhaust pressure, the horse power increases proportionately to the piston speed. With any one ratio between diameter and stroke, the horse power is proportionate to the piston speed and the two-thirds power of the cylinder volume. Thus, under these conditions, the bulk of the engine needed to give a desired horse power decreases as the one and a half power of the speed is increased. The cost of construction does not decrease quite so fast as in this ratio, of course; but up to certain limits, where high linear speed begins to give trouble at glands, etc., it certainly decreases faster than inversely to the first power of the speed. It should not, however, be forgotten that since, for a given desired horse power, increase of piston speed lessens the dimensions and thus shortens the stroke, therefore increase of rotary speed accompanies that of linear speed, and at a faster rate—in the ratio, indeed, of the one and a half power of the linear speed. Thus, whatever advantages accompany high rotary speed will appear progressively in a line of engine designs made out for graduated piston speeds, and will do so very markedly.

Up to certain limits high piston speeds bring with them increased frictional efficiency. The disadvantages concomitant to such speeds are indicated by the limits above referred to. They are reached when piston rings begin to heat unduly and when glands get overheated and leaky. With regard to glands, it is too often forgotten that leakage produces heating—directly by the heat of steam penetrating to the body of the packing and indirectly by the escaping steam preventing the lubricant acting on the rod, and thus provoking excessive friction. Other limiting disadvantages are pointed out below; they are common to high linear and rotary speeds.

Let us ask now why high rotary speeds are prized. It is a well-known historical fact that they were first popularized in order to make direct coupling to fans possible. It must not be forgotten, however, that the Porter-Allen engine, exhibited in 1862, was introduced in order to supply a much cheaper and lighter engine than the now old-fashioned beam engine, which was previously in favor. Not only for fans, but for every kind of driven machinery, direct coupling is a very great boon. In some classes of machinery the difficulty is to let the motor run slow enough for direct coupling. An instructive example is that of tramway and railway electro-motors; but very numerous other kinds of slow-running machinery, ordinarily steam driven, will at once occur to every engineer's mind. On the other hand, it is not small dynamos alone that need to be driven too fast for direct coupling to any ordinary steam engine; very numerous classes, such as fans and small centrifugal pumps and many kinds of machine tools, it is quite impossible to direct-couple to the very fastest steam engines, except steam turbines. High rotary speed in steam engines runs from 300 up to at most 800 revolutions per minute. This range covers a very considerable proportion of ma-

* The Engineer.

chine speeds requiring driving power, and with the whole of this direct coupling is a theoretical possibility; but it must at the same time be remembered that a still larger proportion lies outside this range. It must also be considered that with the demand for larger electric powers, dynamos of small diameter and of high rotary speed now occupy a much smaller place on the market than they formerly did.

There are other less apparent advantages of high rotary speed. Chief among these is the diminution of cylinder condensation often claimed, and the consequential important rise in steam efficiency in the cyclic action of the engine. Condensation of steam requires time, and the shorter each period during which the cylinder walls remain cooler than the steam the less should be the proportion of steam condensed. Dryness of the walls is of equal importance, but no mode of jacket heating or steam superheating will, it is held by many engineers, produce this dryness except under the condition that the duration of each period of steam cooling is reduced to the necessary limit.

As high piston speed gives each desired horse power with correspondingly low driving force, so also high rotary speed gives the same result with low driving torque. Now, in shaft transmission of power low driving torque is a very conspicuous advantage, leading to great diminution of constructional cost all along the line in bearings and brackets, shaft diameter, etc. The economy here is exactly on a par with that obtained in electric transmission by the use of high voltage. The system, of course, labors under the difficulty that it ordinarily involves letting down the speed at the far end, where, at or near the working point, a large torque is essential, and where reducing gearing has to be introduced. The cost in construction and in efficiency of this gearing neutralizes some part of the gain obtained in the transmission, and thus below a certain length of transmission, the advantage of high rotary speed transmission disappears. The limit of length depends upon the conditions required to be fulfilled at the working end.

The troubles common to both high linear and rotary speeds are all connected with accelerations. The most annoying to the mechanic is, without any doubt, the beat at the crosshead and crank pins at the reversal of the stroke. In an ordinary double-acting engine there occur four reversals of pressure at these joints if the speeds go above a certain limit dependent upon the initial pressure and upon the cut-off. This marks an absolute limit for each engine beyond which no considerations of any kind whatever excuse the raising of the speed. Except under distinctly improper circumstances, there are two reversals per stroke. In the "high-speed" vertical single-acting engine the difficulty is avoided by a top air or steam cushion keeping the joint pressure continuously downward, but this is invariably accomplished only at the price of single in place of double action, and consequent halving of the effective speed, whether that speed be reckoned in linear or rotary units. The harm done by these reversals increases with three things: the number per minute, the amount of the sudden change of pressure, and the slackness of fit between pin and brasses.

The violence of each blow and the number of blows per minute may be taken as each equally influential in the work of destruction. Herein lies the strongest argument against high rotary speed, an argument from which there is no possible escape. For given horse power one can get high linear speed with a small number of joint-pressure reversals per minute by departing from ordinary ratios between stroke and diameter and adopting long strokes. No similar mode of avoiding the difficulty can be devised, of course, to mitigate the effect of high rotary speed.

Of the three factors, slackness of fit is no doubt the most injurious and the most difficult to find means of avoiding. A tight fit is inadmissible, not only because of the resulting friction, but still more on account of an intermittent light pressure being essential to permit the inflow of lubricating oil. Even supposing reform of the usual absurd method of oiling from the center of the bearing area, where the bearing pressure is most intense, to be effected, still no crank pin bearing has ever been successfully lubricated without a large periodic variation of pressure. The key to success in this respect lies in noting that for proper free entrance of oil it is unnecessary for the pressure to go down to zero; it only needs to go to a low intensity. As the pressure intensity goes down, the surfaces, which ought never to be in actual solid contact, but always separated by a film of oil, spring apart and suck in oil. They should never spring so far apart as to break the film of oil. This sucking in of oil does not involve zero pressure, a lowering of pressure below a limit dependent on the capillarity of the oil is all that is needed. At least two makers of double-acting engines have made ingenious, and apparently successful, efforts to keep up continuous contact under slight pressure, while the heavy pressure is alternately thrown on one and the other side, and at the same time to maintain the proper closeness of fit by automatic compensation for wear by the action of springs thrusting the brasses against the pin.

The amount of the sudden change of pressure is, so far as it depends on admission and exhaust of steam, unmodifiable except by adapting steam or air cushioning to the acceleration of momentum of the reciprocating parts. Even such cushioning only modifies the suddenness, it does not, and cannot, affect the amount of change of pressure; it may result in the change being spread over 0.02 instead of 0.01 of a second. Then the balance between acceleration and cushioning can be correct only for normal speed and normal steam pressure; deviation from normal in either respect entirely upsets the balance. The throw of the masses is generally responsible for the worst of the knock, that is, the centrifugal effects make the worst difficulties. These effects are proportional to the weight of the reciprocating masses, and to a function of the speed which may be expressed either as $V\ N$, or $N^2\ S$, or $V^2 \div S$; where V, N, and S are piston speed, rotary speed, and stroke. The last expression shows how all such difficulties are reduced for given piston speed by lengthening the stroke. The first, V N, a form of expression too often overlooked, because never found in text-books, shows that for given speed of either sort the difficulty is raised by increasing the other kind of speed; and that the effect is influenced symmetrically by both kinds of speed. The expression $N^2\ S$ shows that for given rotary speed increase of stroke raises proportionately these acceleration troubles. Thus large horse power per unit of bulk of engine is not possible with high rotary speed.

Finally, we may usefully compare the engine horse-power with the acceleration troubles arising from the reciprocating masses. The weight of these masses throughout the range of one line of design may be taken to vary very nearly in proportion to the whole steam pressure on the piston, or $p\ D^2$, while the horse-power is proportional to $p\ D^2 . S\ N$ or $p\ D^2 . V$. Thus the ratio of horse power to acceleration effect is $p\ D^2 . S\ N \div p\ D^2 . S\ N^2$, that is, $\frac{1}{N}$. Otherwise stated, the horse power attainable, so far as it is governed by centrifugal troubles, is inversely proportional to the rotary speed. This result, which has not been commonly observed, indicates perhaps as clearly as any other what are the limits of usefulness of high rotary speed in engines of the piston type.

The same ratio $\frac{1}{N}$ may, of course, be written $\frac{S}{V}$, which shows that such troubles are of worst influence in small engines, and that to keep even with them in passing from large to small sizes we would need to reduce piston speed in proportion to stroke.

[Continued from SUPPLEMENT No. 1383, page 22163.]

MESCAL: A STUDY OF A DIVINE PLANT.*

By HAVELOCK ELLIS.

IV.

THE experiment just described may be regarded as fairly typical of the effects of mescal in an ordinarily healthy subject, so far as my observations extend. There are, however, very wide individual variations in the effects of the drug, as have been made clear by subsequent experiments which I have made on other persons. It may, therefore, be of interest to present another experiment for the sake of comparison. In this case the subject was not under my own immediate observation; I should not myself, indeed, have given him mescal at all, knowing that in such a case the experience would certainly not be altogether pleasant. The subject was an art-student, 26 years of age and 6 feet in height, a Highlander on the father's side, and a Lowlander on the mother's, presenting the type of the red-haired, beak-nosed Highlander. Though never ill, he is never in good condition, muscles flabby, skin clammy, pulse liable to be weak and intermittent, without reserve of mental or physical energy. He had severe rheumatism ten years previously. He is lazy and drinks and smokes to excess. He gives the impression of a man of splendid physical race, who has somehow not reached the perfection of his type. Altogether, so far as mescal is concerned, I should regard him as an unlikely subject for what the Indian would call a "beautiful intoxication." But the experiment which I give in the words of the very good observer who conducted it is not on that account the less interesting.

"The first dose was administered, after a fair meal, at 4.30 P. M. No nausea was at any time experienced. Pulse 96.

"5.00 P. M. The pulse was 86.

"5.30 P. M. The pulse was 62, flaccid and compressible, with a perceptible second beat, and rather intermittent. The subject had been lying in the veranda of the bungalow since 4.30 P. M. The second dose was now given.

"5.45 P. M. The pulse was 60, and remained at 60, except during exertion, for the next twenty hours. The pulsations were now occurring in a strongly staccato fashion. There was no perceptible second beat, and the pulse was not so compressible.

"6.00 P. M. The pulse was no longer staccato, but distinctly intermittent. It was, however, stronger, and but little affected by holding the wrist above the head.

"6.30 P. M. The third dose was given at 6.30, and the subject came indoors, and was wrapped up in a chair facing the open door, and looking out to sea. A deep, sudden breath now caused a marked acceleration in the heart's action, and rising from a lying to a sitting posture sent up the pulse from 60 to 80, for a space of ten seconds or so.

"6.45 P. M. A feeling, neither pleasant nor unpleasant, of general lassitude and indifference, and a slight sensation of rigidity in the backs of the fingers when extended. The same feeling was present in a less degree all over the body, giving the subject the impression that the motor nerves were becoming partially paralyzed. Otherwise the subject was perfectly comfortable, though somewhat weak and lethargic.

"7.00 P. M. The pulse was alarmingly intermittent. There was often a pause of two seconds between beats. However, the subject was quite unaware of the fact and perfectly comfortable.

"8.00 P. M. The subject complained of difficulty in breathing, as though a tight bandage were tied over the left side. The pulse was now almost, and sometimes quite, imperceptible. The arms became weak; in a few minutes they became absolutely paralyzed. The subject began to be a little scared. However, in about ten minutes the loss of power passed away, and he became perfectly comfortable, though disinclined to move a finger.

"8.45 P. M. The sea suddenly turned purple and tilted up to the eaves of the veranda, and instantly regained its normal aspect. The victim was not particularly excited at this sight; indeed, throughout the experiment I was struck by the very matter-of-fact way in which he received the various visions, I myself being far more keely interested in them. The legs now became partially paralyzed for a few minutes. There was no other symptom whatever till 8.45 P. M. when very indefinite stationary spots of purple and blue-green were seen on the beach at a distance of fifteen or twenty feet. They gradually assumed the shape of rather conventionalized thistle-heads, some purple and some emerald. For a moment the shingle beach appeared to be turning into a bed of flowers, but they quickly faded away. When I went out and struck a match before the bungalow the flowers suddenly reappeared. Whenever a match was struck they became more vivid. It was now twilight and when the flowers appeared the beach became brighter.

"I now lit the lamp and placed it by the subject. The thistles had faded away. Suddenly the sea—which was gray—turned green, and became covered with symmetrically arranged spots of violet, which rotated on their axes and passed off to the right. There were three bathing-machines half way down the shingle, and the spots passed behind them.

"I now turned down the lamp. The shingle instantly became a bed of blue flowers; some unknown little plant which produced a short spire of blue blossoms, and a few green blades. I asked the subject to direct me to one spire which was higher than the others, and trod on it, when it disappeared. I turned up the lamp; the flowers disappeared.

"The subject now saw a large cutter about half a mile from shore, which sailed rapidly along and passed behind the bathing machines. He made a sketch of it as it approached, to give me the relative proportions of the cutter and the machines, and then described it as close in. As a matter of fact there was a small cutter about a mile off shore, and about one-tenth the size of his sketch.

"9.25 P. M. On the beach, where the flowers had been seen before, a head like the Cheshire Cat appeared. It was vague, except for the smile. Presently it developed a body and legs, and became a lynx, with no feet, and eyes like glowing opals. It danced gravely round in a circle. Having inquired as to its exact position, I went out and kicked it. It vanished.

"The subject now saw, in the wake of the moon, which was now shining brightly, a boat containing two men fishing, with a light. I could see the two men only with the telescope. Handing the subject the telescope, he said that he saw the boat three times as large without the glass. He now came out and leaned on the rail of the veranda. A cloud over the moon appeared to him an oared galley, five times the diameter of the moon. The oars were moving at the rate of 30 strokes to the minute.

"10.15 P. M. The galley having disappeared, the subject sat down inside the door again. A creature with a pointed nose and sharp ears popped its head constantly round the corner of the door. As the pulse was again imperceptible I administered a pint of strong coffee.

"10.45 P. M. A beautiful miniature Eastern city appeared on the beach about twelve feet away. It was lit, apparently, by the sun; there were walls, citadels, mosques, minarets, houses, etc. all white, interspersed with green foliage. It was very compact, standing high above the walls, and about six feet in diameter. After some five or ten minutes an enormous tortoise, with a Greek key pattern in metal round the periphery of the carapace, walked against the city and right through it, when it disappeared, and the tortoise with it.

"Shortly afterward a vast horde of little black woolly animals, rather like black guinea-pigs with astrachan coats and glow-worms for eyes, poured up over the pebble ridge from the sea, and disported themselves over the beach, which was quite covered with them. After pouring up for a minute or two they vanished into thin air. Their motion was like that of a swarm of maggots discovered in turning over a dead animal. This was the last vision. The subject expressed a desire for a very large meal, ate a small one, went to bed, immediately slept a dreamless sleep, and was for two days very 'anguid and weak, with a feeble and depressed pulse, and occasional palpitation. He will on no account try the experiment again.

"The most remarkable feature of the visions was that they all had 'a local habitation and a name.' They all appeared out of doors, most of them on the ground at a distance of twelve feet or so; they did not move when the head or eyes were turned, but kept exactly in their place. The visions were seen with either eye indifferently; with the eyes closed nothing was seen. Mechanical pressure on the eyeballs had no effect. At one period of the experiment the muscles of the eyes became relaxed, so that the subject saw near objects slightly doubled."

V.

It may be seen from the two experiments which I have described in some fullness that, in general character, the physical and psychic manifestations of mescal somewhat recall those produced by haschisch, the most famous and typical of the "artificial Paradises" which man has found for himself. No other drug, indeed, can be said to approach so nearly to haschisch in its effects. They are alike in the variability of their effects on different individuals and in the difficulty of obtaining a reliable preparation.* They both slow the heart, tending in some cases to produce intermittence, and both affect the respiration. They both produce muscular weakness and incoordination, exaggerate the knee-jerk and dilate the pupils. They both, moreover, possess the same vision-producing properties. I cannot speak from personal experience on this point, but one of my subjects, a poet who has paid much attention to the methods of generating visions, assures me that in his experience the virtues of the two drugs are about equal and that he has no preference for haschisch over mescal.

While there are thus marked and fundamental resemblances between mescal and haschisch, there also appear to be numerous points of difference.† On the

* Popular Science Monthly.

* Haschisch is said to vary in accordance with season, as well as with the district in which the hemp is obtained. The Indians believe that mescal is only active at one season of the year. I found one supply that reached me to be almost or quite inert, and it is possible that it was gathered out of season.

† The resemblances between haschisch and mescal come out most clearly in the latest and most reliable investigations, see, e. g., W. E. Dixon,

whole it may be said that mescal has a more restricted, a less generalized action than haschisch. In some of the early accounts of haschisch, which may now almost be said to be classic, great stress was laid on its exuberant motor manifestations, the uncontrollable antics, and the loss of all sense of time. These manifestations are much less conspicuous, and often do not appear at all, in the later accounts of haschisch, so that they are evidently not essential.

Under mescal, so far as I have been able to observe, they seldom appear. Mescal may at one stage produce a sense of well-being, vigor and intellectual lucidity, and there is no actual motor exhilaration, or loss of self-control, usually no mental failure at any point, except that when the influence is strongest attention may be impaired, so that one realizes when under mescal how much attention is a matter of muscular coordination. The action of mescal on the motor system is to depress, so that there is a tendency to tremulousness of the muscles which feel weak, and it seems to the subject that he must exert more than usual care to prevent himself from staggering and more than usual energy to perform even the simplest action. This may affect space-relations and one of my subjects found that in lifting a cup to his lips the distance traversed seemed very much more than usual; the same subject found that his ideas of time seemed to be disturbed, but on testing him with the watch his estimates were found to be fairly accurate.

The positive and active manifestations of mescal are always mainly if not entirely on the sensory side, and the motor weakness and sense of lassitude which is often present only throw the subject of mescal intoxication more absolutely at the mercy of the waves of unfamiliar sensory impetus which strike him from every side. Every sense is affected: apart from the various visionary influences, sounds become unfamiliar and abnormally acute, the sense of smell is stimulated or olfactory hallucinations may occur, the simplest food seems to possess an added relish, while there are vague skin sensations, and to the sense of touch the body seems as unfamiliar as everything else has become. I have elsewhere remarked, in illustration of the peculiar effects of this drug, that mescal seems to introduce us into the world in which Wordsworth lived or sought to live. The "trailing clouds of glory," the tendency to invest the very simplest things with an atmosphere of beauty, a "light that never was on sea or land," the new vision of even "the simplest flower that blows," all the special traits of Wordsworth's peculiar poetic vision correspond as exactly as possible to the actual and effortless experiences of the subject of mescal.

It should be added that a sense of well-being is not an essential part of these sensory manifestations. In this respect mescal is entirely unlike those drugs of which alcohol is the supreme type. Under the influence of a moderate dose of alcohol the specific senses are not obviously affected at all, but there is a vague and massive consciousness of emotional well-being, a sense of satisfaction tending to a conviction that "all's well with the world." Alcohol has a dulling influence on sensory activity and on the intellectual centers; and it may indeed be said that for the brain-worker whatever value the moderate use of alcohol may possess chiefly lies in the fact that after brain-work is over it helps to soothe undue brain-activity. Mescal, on the other hand, is not mainly emotional in its effects but mainly sensory and it leaves the intellect almost unimpaired even in large doses. It is true that in one stage of mescal intoxication, and more especially in quite healthy persons, there is a feeling of well-being, and even of beatitude, accompanied by an illusory sense of quite unusual intellectual activity; but there is no stage of maudlin emotionality; on the whole there is a condition of fairly unimpaired and alert intellect, untiringly absorbed in the contemplation of the strange world of new sensory phenomena into which the subject has been introduced.

These phenomena are above all visual, and the intellectual character of mescal intoxication as compared with perhaps any other intoxication, seems connected with the fact that it is the most intellectual of the senses that is chiefly involved. The visual effects of mescal may be of very various character, largely depending on the idiosyncrasy of the subject as well as on the degree of the intoxication. They vary from an exaggeration of the normal phenomena, producing a heightened play of light and shade and color, to visions seen on the curtain of the eyelid with closed eyes and with open eyes in the dark, up to actual localized hallucinations seen in broad daylight. It seems reasonable to suppose that the cerebral centers of vision are affected under mescal, and the occipital headache which occasionally follows supports such an assumption; a merely peripheral stimulation could scarcely suffice to account for such an orgy of vision. But at the same time I am convinced that the conditions produced in the eye itself are important factors in the production of the phenomena. Not only must we suppose that the retina, like all the sensory apparatus, has become hyperæsthetic, but the pupils are dilated, so widely dilated in one of my subjects that there was extreme photophobia. It is probably not without significance that in the other chief vision-producing drugs, such as haschisch and belladonna, the pupils are also dilated. It is evident that light can penetrate into the chamber of the eye with much more ease than usual. The Kiowa Indians sit around a fire during the nights on which the mescal rites are performed and I have found that the flicker of fire-light acting through the closed eyelids furnishes a very favorable condition for seeing the visions to advantage.

There is another characteristic of a large number of these visions (as indeed of many visions otherwise produced) which, it would seem, we must explain through peculiarities of the eye. I refer to what I have termed their kaleidoscopic character, the tendency to symmetrical grouping in the visual field of objects similar in shape, and harmonious though not necessarily similar, in color, so that a kind of vision is produced such as we might attribute to an animal with faceted eyes. We might account for such a phenomenon by means of that irregular astigmatism, found more or less in normal eyes, which has been attributed to the fact that the crystalline lens is composed of many sections connected by radial sutures, or, more plausibly, with Sheiford Bidwell, who has made some interesting experiments on this point, to the light passing through the coarse-meshed tissues of the eyes.* With perhaps still greater probability we might adopt the suggestion of Zehender† who in dealing with subjective visual perceptions would explain the strikingly regular polygonal figures which arise under various conditions to the movements and displacements of retinal pigment grains in course of chemical decomposition.

There is another visual phenomenon caused by mescal, to which my attention was particularly attracted, since it appears to have been little noticed by previous observers, and which is of considerable interest because it may be brought into line with various phenomena which occur without the intervention of drugs. I refer to the play of shadowy color, and more especially the violet halos which are seen to play around and over objects and constitute, in my own case at all events, the earliest group of color phenomena seen under mescal. I have already described my impressions to this effect, and one of my subjects who saw the same phenomenon, describes it as "a violet fringe, surrounding objects and tending to become flower-like." It has been observed by many when passing over snow-covered regions, and especially by Alpine climbers, that moving objects, and more especially their own hands or garments, show a violet border.‡ Then we have the tendency to color vision (erythropsia or perhaps more strictly, or more usually, violet vision) to which the eye becomes liable after surgical removal of the crystalline lens. Once more there are the colors produced by the much discussed colorless "spectrum top." It seems to me that all these phenomena, and others that could be named, must be regarded as more or less allied. The first explanation offered for the earliest of them to be noted was that they are due to overstimulation and exhaustion of the eye. Later inquirers have sought after a more precise mechanism for the phenomenon. Thus Dobrowolski in 1887, dealing with the erythropsia often occurring after removal of the lens, argues that a necessary condition is the dilatation of pupil produced by atropine, and that the color vision is really of the nature of a negative after-image of the rays that strike the eye. Fuchs, in 1896, who has dealt in an interesting manner with the erythropsia experienced on climbing snow-covered mountains (regarded by him as strictly a purple vision) finds that Dobrowolski's explanation is inadequate, and, while contenting himself with the theory of stimulation and fatigue for some of the phenomena, believes that the real explanation is to be found in a temporary visibility of the visual purple of the retina. Whatever the value of this explanation may be as applied to the whole group of phenomena, Fuchs more than anyone helped to bring color-visions of this kind from the sphere of the pathological into the sphere of the normal. More recently still, Shelford Bidwell in 1897, when making some simple but ingenious experiments with the object of discovering the mechanism of the spectrum top, found that when a dark patch is suddenly formed upon a bright ground the patch appears to be momentarily surrounded by a blue border, and he accounts for this by the theory of a sympathetic affection of the red nerve fiber; when light is suddenly cut from a patch in a bright field, there occurs an insensitive reaction in the red fibers just outside the darkened patch, in virtue of which they cease for a short time to respond to the luminous stimulus, in sympathy with those inside the patch. The green and violet fibers, by continuing to respond uninterruptedly, give rise to the sensation of a blue border. Where highly competent experts fail to agree it would be rash to state any definite conclusions. It is difficult, however, not to believe that, whatever the precise retinal process may be, over-stimulation and fatigue certainly have very much to do in calling it into action. Associated with the violet halo, as we have found, there is a tendency under mescal, especially by the aid of a bright flickering light, for shadows generally to be variously colored, more especially (as in erythropsia and allied conditions) toward the outskirts of the visual field. Anyone who will sit for a few minutes with his eyes directed on a sheet of white paper illuminated by bright sunlight will soon begin to see on a small scale a faint reproduction of the colored shadows seen under the influence of mescal. Here clearly we have a fatigue phenomenon due to over-stimulation by bright light, and precisely analogous to the after-images produced by looking at any excessively bright object. Under mescal we have a similar effect produced, not through the stimulation of unusually bright light, but by the unusually hyperæsthetic condition of the visual apparatus, due in part to the dilatation of the pupil and in part to the effect of mescal on the retina.

There is one other effect of this fascinating drug to which attention may finally be called. It has been pointed out that under mescal all the peripheral sense organs become highly irritable or hyperæsthetic. Not only is this so, but they are brought in a quite unusual degree into sympathy with each other. I found that causal stimulation of the skin at once heightened the brilliancy of the visions, or produced an impression of sound. One of my subjects, an artist, had a curious sensation of tasting colors, and another found that music had a delightful influence over the visual effects. This, and the fact that the Indians keep up a continual beating of drums during the time they are under mescal, led me to plan a further experiment on myself with mescal. I arranged that when the stream of visions was in full force a friend should play to me on the violin various pieces of a more or less progressive character which were unknown to me, at all events by name. I found that these pieces, more especially those which were somewhat uniform and monotonous, not only distinctly stimulated the visions, but influenced their character; and in about half the tests there was a real resemblance, sometimes in a striking manner, between the prevailing nature of the visions and the name of the piece. This was especially the case as regards Schumann's music. It would be worth while to carry out further experiments along this line, and on a variety of people, preferably non-musical people. It may be added that under some circumstances music itself invokes a train of visual imagery. Heine has somewhere described in detail the imagery called up when listening to Berlioz's music, and in "Florentine Nights" he describes, in the person of his hero, the elaborate imagery evoked on hearing Paganini play, and remarks: "You know my second sight, my gift of seeing at each tone a figure equivalent to the sound, and so Paganini with each stroke of his bow brought visible forms and situations before my eyes; he told me in melodious hieroglyphics all kinds of brilliant tales; he, as it were, made a magic lantern play its colored antics before me, he himself being the chief actor." It would seem that in Heine's case music produced actual visual imagery, as under the influence of mescal. In this connection I may recall an account of visual imagery, as seen at a concert recorded by Dr. Robert MacDougall.*

One is tempted to ask by what process we should conceive to ourselves that the action of mescal works on the organism. I think it is not impossible to hazard such an explanation, provided that we avoid the risks attending undue precision in our explanations. We are justified, it seems to me, in supposing that mescal effects its peculiar actions by producing a kind of violent but temporary neurasthenia and cerebrasthenia. In other words, it rapidly overstimulates and exhausts the nervous and cerebral apparatus, more especially on the sensory side. It is true that such an explanation might be said to apply to the action of many drugs, including all those that are commonly called stimulants. The day has gone by when it could be supposed that a stimulant put anything into the system. It acts not by putting energy into the system but by taking it out, and so rapidly producing a state of fatigue. The careful experiments of Féré with the ergograph have lately shown that all sorts of sensory stimulants, acting on various senses and not necessarily involving the use of drugs, produce an immediate increase in the output of muscular work, but that no sensory stimulant of any kind will enable us to do a total amount of work equal to that we can achieve without stimulants, because the sudden rise of output is more than compensated by the subsequent fall. So that by the use of stimulants, so far as output of work is concerned, we not only draw on our capital, we actually dissipate and waste it. But the results of this kind of fatigue do not usually produce any condition comparable with neurasthenia; they do not, for instance, produce visions. In neurasthenic states there is, however, a tendency to visionary effects—colored vision, intolerance of light, photopsiae, persistence of retinal impressions, etc.—and, moreover, in all temporary conditions of nervous fatigue in otherwise fairly healthy people the same tendency to abnormal color effects with open eyes, and vague visions with closed eyes, is apt to show itself. I find that some persons, when very tired, see shadows as unusually violet, while kaleidoscopic visions and processions of figures and faces are also seen with closed eyes after fatiguing days. I have myself noted effects faintly recalling those produced by mescal after periods of unusual brain activity. On the borderland and between sleeping and waking color-visions are also sometimes seen, and Mrs. Christine Ladd Franklin has stated that in falling asleep over a book she sees colored shadows, especially violet, floating over the page. It is noteworthy, further, that in various conditions of abnormal color-vision fatigue increases the brilliancy of the colors. The same tendency rules the association between music and visions. Heine was a somewhat neurotic subject who constantly complained of very severe headaches, and Dr. MacDougall, in describing the physical conditions under which he finds that visual imagery is liable to occur, describes a state approaching that produced by mescal: "In the earlier stages of fatigue, before the final condition has been approached, a period of cerebral excitement occurs, often accompanied by slight frontal heachache, in which my mental imagery becomes more varied and concrete than normal. I feel an unusual brilliancy and fertility of suggestion; my mental scenery becomes less schematic and algebraic; comparisons and illustrations suggest themselves on every hand; thought proceeds by object images." It may be pointed out that neurasthenia is widely regarded as a condition of depression with irritability of the higher cerebral centers. Binswanger, indeed, in his book on the pathology of neurasthenia considers the parallel between fatigue and neurasthenia as so close that he is inclined to regard the latter as nothing else than a prolonged condition of over-fatigue. In mescal intoxication we may be said to have a neurasthenia which is very limited, but is very sudden and swift. The sensorial apparatus is allowed to run violently down, and in healthy persons the accompanying acute metabolic activity produces the pleasurable feelings which usually accompany nervous activity. It is perhaps due to the swiftness of this process, and also to the good physical condition of the subject, that no unpleasant after-effects are usually experienced. I have noticed that the pleasant or unpleasant effects and after-effects of mescal may be quite accurately foretold from a knowledge of the subject's general health, and that the better his general condition the less likely is he to experience any unpleasant results from taking mescal.

"The Pharmacology of Cannabis Indica," British Medical Journal, November 11, 1899, and E. B. Delabarre, "Report on the Effects of Cannabis Indica," Psychological Review, March, 1900. The latter is only a brief summary, but Prof. Delabarre informs me that he hopes to publish a full account of his investigations.

* Shelford Bidwell, "Multiple Vision," Nature, April 13, 1899.

† Klinische Monatsblatt für Augenheilkunde, November, 1895.

‡ This phenomenon was discussed in Nature, during May, 1897, some of those who described it assuming without question that it was an objective phenomenon.

* "Music Imagery," Psychological Review, September, 1898. The cases in which some definite appearance is regularly associated with the sound of each instrument belong to an allied though different class; a case of this kind is recorded in Nature, March 6, 1890. Here we approach the best known group of "secondary sensations."

It was inevitable that an attempt should be made to drag mescal into the already overcrowded field of therapeutical agents. Curiously enough, the first affection which it was used to treat was neurasthenia, and the results were said to be good, but nothing further has been heard of it. In various quarters it has been suggested for use in insanity, and at Carmarthen Asylum Dr. Goodall, as he informs me, has made many trials with it, on melancholic and stuporose patients, pushing the drug eventually in large doses, but beyond dilatation of pupils and rapidity of heart action, the results were nil. I have myself never felt hopeful about mescal as a therapeutic agent, and though it is possible that of the various alkaloids obtained from it some may be found useful, it is not easy to see in what diseased conditions the crude drug itself is indicated. The fact that its best results are obtained in perfectly healthy individuals would alone counter-indicate its use as a remedial agent, and at present there seems no excuse whatever for thrusting it into the pharmacopœia.

The chief interest of mescal is for the physiologist and the psychologist.* It may be added that for every healthy person a single experience, at all events, of what mescal has to teach would be an educational advantage of no little value. As one of my subjects, who strongly feels this educational value of mescal though he has no wish to repeat the experience, remarks: "The connection between the normal condition of my body and my intelligence had broken—my body had become in a measure a stranger to my reason—so that on reasserting itself it seemed, with reference to my reason which had remained perfectly sane and alert, for a moment sufficiently unfamiliar for me to become conscious of its individual and peculiar character. It was as if I had unexpectedly attained an objective knowledge of my own personality." Thus it is that the Indians who raised this remarkable plant to divine rank, and dedicated to it a cult, have in some measure been justified, and even in civilization there remains some place for the rites of mescal.

* "What an excellent use for a medical congress," Mr. Francis Galton writes to me, "to put one-half of the members under mescal, and to make the other half observe them."

MAGNETIC SEPARATORS.

THE magnetic separator is an important economizer which finds its principal field of usefulness in brass foundries where it is desirable to remove all iron from scrap before melting. It is also a valuable labor saving device for large machine shops, and in this connection it saves much valuable material by separating magnetic from non-magnetic turnings, filings, and chips.

The operation of the separator may be explained by reference to the accompanying diagram. The mixture of metal filings, turnings or chips is placed in the hopper at the top of the separator and feeds slowly down on the surface of a revolving brass drum, within which an electro-magnet is so arranged that it retains the magnetic metal on the surface of the drum until it is scraped off on the right-hand side of the partition and into the bin. The non-magnetic metal falls directly into the bin on the left side of the partition.

The frame is constructed of heavy ash filled and finished with oil and shellac. The parts are firmly bolted together and strengthened by angle irons. The hopper is made of heavy sheet metal, and is supported at one end by a pivot and at the other by two swing links. A rod connected to the hopper swings it back and forth when the separator is in operation so as to distribute the metal on the surface of the drum. An adjustable grate is provided so as to regulate the flow of metal from the hopper. The length of the swing of the oscillating mechanism is adjustable.

Current is supplied to the electro-magnets within the drum through collector rings and carbon brushes. The flanges at the edges of the drum keep the metal on the surface. The metal is stirred to aid in separation by two wires supported from the frame and extending across in front of the cylindrical surface. The brush wheel which removes the iron from the cylinder has radial strips of sole leather secured between wooden blocks. This wheel rotates in the same direction as the drum, but at a much higher speed. The bins into which the separated metals are dropped are situated within the frame and open at opposite ends of the separator so as to prevent the metals from becoming mixed in handling. The bins are lined with sheet iron.

The separator is driven by a pulley mounted on the brush wheel shaft. An idle pulley is also provided for use when the separator is driven from a line shaft. The drum is driven from the pulley shaft by a sprocket and gear chain which is shown in the diagram. The hopper is rocked by a connecting rod mechanism from a crank on the brush wheel shaft.

The separator has a rated capacity of 600 pounds per hour and a maximum capacity of about 900 pounds per hour. It requires ⅛ H. P. to drive, and the speed of the driving pulley is 110 revolutions per minute. The electro-magnet requires about 75 watts and may be wound for 110, 220 or 500 volts direct current.

The separator operates satisfactorily with any mixture of magnetic and non-magnetic metals, but when the mixture contains considerable oil it may be necessary to run it through the separator twice.

The machine requires a floor space of 20 inches x 48 inches. Its height over all is 55 inches and its weight about 750 pounds. The pulley is 12 inches in diameter and has a 2½ inch face. The machine is made by the General Electric Company, of Schenectady, N. Y.

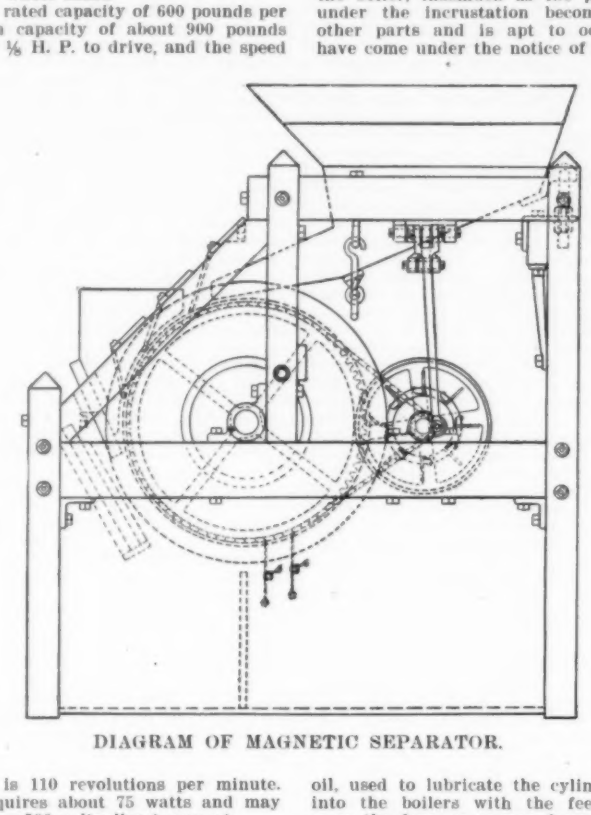


DIAGRAM OF MAGNETIC SEPARATOR.

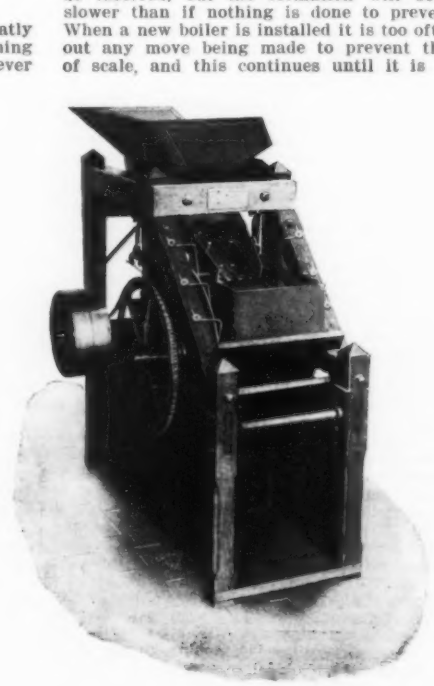
BOILER SCALE SOLVENTS.*

By D. B. DIXON.

A BOILER free from scale and corrosion is greatly desired by all engineers, but is a very difficult thing to attain in practice. Boiler feed water is never found chemically pure, always containing foreign substances in solution, and when boiled until it all escapes as steam, we find on the bottom, sides and tubes of the boiler a coating or deposit, which, if hard, we call incrustation or scale; if in the form of a powder, we call it sediment. The water also holds mineral matter in a state of mechanical suspension. Incrustations are injurious to boilers because they are poor conductors; cause loss of heat and waste of fuel estimated from 15 per cent to 40 per cent of the fuel used, dependent upon thickness of the scale; cause over-heating of the boiler plates, which is sure, sooner or later, to burn out the metal, and may result in an explosion of the boiler; and corrosion of the metal occurs rapidly in parts of the boiler upon which the deposits are more liable to accumulate. Incrustations due to the deposition of matter held in solution in the water have only been spoken of, as those are by far the most frequent. But it is known that a quantity of fatty matter in the feed water of a boiler causes a deposit, and that this may lead to the destruction of the boiler, inasmuch as the part of the boiler shell under the incrustation becomes more heated than other parts and is apt to occasion rupture. Cases have come under the notice of boiler inspectors where oil, used to lubricate the cylinders, has been carried into the boilers with the feed water, and settling upon the furnace crowns formed a thin, hard incrustation, which resulted in burning the plates, followed by a crack necessitating repairs.

The best means to prevent incrustation is the purification of the water, or the removal of the incrustants before the water enters the boiler. In order to ascertain whether and how a certain feed water can be purified to the best advantage, it is necessary to have a sample of it analyzed. The sample should be put in a clean new jug and not be less than one gallon. There are certain things that may be done to prevent rapid scale formation in boilers located almost anywhere. That no scale will form is not to be inferred, but the formation will be very much slower than if nothing is done to prevent it at all. When a new boiler is installed it is too often run without any move being made to prevent the formation of scale, and this continues until it is seen on the tubes and plates. Then a decided move is made, but usually it is too late, for the methods adopted are too mild to cope with scale forming on the scaled surface. If a boiler is taken in time and before the scale has accumulated to any appreciable extent—whether the boiler has just been thoroughly cleaned or is new does not make any difference—and a surface and bottom blow-off are opened several times a day, it will be found that the formation of hard scale will take place much more slowly. Even when the water is very bad, a good surface blow-off device properly placed in the boiler will prevent scale formation. There are many compounds on the market for preventing incrusta-

* Mining and Scientific Press.



MAGNETIC SEPARATORS.

tion: some are very costly, and few of them are alike applicable to all cases. Some of them increase corrosion of the boilers while they prevent incrustation, and in the employment of others practical difficulties arise which render their use inconvenient and even dangerous. Slab zinc is often used in boilers and hot water tanks to prevent scale formation and the corrosive action of the water on the metal of which the tank or boiler is composed. The action appears to be an electrical one, the iron being one pole of the battery and the zinc being the other. Under the action of the current of electricity so produced, the water in the tank is slowly decomposed into its elements, oxygen and hydrogen. The hydrogen is deposited on the iron shell, where it remains. It will not unite with iron to form a new compound, but if any iron rust is present it will remove the oxygen from this and deposit the metallic iron on the plates. The oxygen of the water that is decomposed, instead of going to the iron, goes to the zinc and forms oxide of zinc, and in the course of time the zinc will be found to be almost entirely converted into oxide. On account of the action outlined, it is generally believed that zinc is always a good thing to prevent both scale and corrosion, and that it cannot be harmful to the boiler under any circumstances. But such is not always the case, and in making use of zinc the boiler should be frequently opened and the action carefully watched, so that if any undesirable effects show themselves they may be checked in time to prevent serious trouble. Carbonate of soda is used to a very great extent as an "anti-incrustator," and it also prevents "pitting." A simple way of adding the soda is to dissolve it in the feed water prior to its injection into the boiler. A sufficient quantity will have been added in all cases where the water (sampled at the gage glass top) will turn a piece of red litmus paper slightly blue, showing that the water is slightly alkaline. A very simple method of removing the incrustation of boilers is said to have been discovered by a French engineer. After extinguishing the fires the boiler water is blown off very gradually, at the same time admitting an equal volume of cold water, so that the water gage shows no change of level. As soon as the water has in this manner been sufficiently cooled down it is suddenly blown off. This latter operation is said to remove the major part of any incrustations which may be present, what remains being very easily detached by scraping. The cleaning of the boiler must, however, be taken in hand immediately upon completion of the blowing-off operation, as otherwise the furstone will harden and adhere again to the boiler plates.

Kerosene oil possesses properties which make it useful in removing old scale from the shell and tubes of a steam boiler, and it is extensively used for this purpose. But, unfortunately, it is not always applied judiciously, hence the many failures attending its use. It can also be used to prevent the formation of scale. We have seen wheelbarrow loads of scale loosened from the shell and tubes of a boiler during a week's run, after kerosene oil had been applied. Three treatments with kerosene oil during three weeks' time left all parts of the interior of the boiler "metallically clean." The greatest difficulty experienced in the successful use of kerosene oil for removing scale is that the quantity usually applied is too small to be of perceptible benefit. Kerosene oil is highly penetrative, and will penetrate through a considerable thickness of any porous substance—especially boiler scale. Ordinary kerosene oil will wholly evaporate if kept at a temperature of about 200 deg. For this reason it is of little benefit if fed into a boiler where the temperature is higher than this, because it will soon evaporate; while it remains it will rest on the surface of the water—very little being carried below the surface by the circulation of the water. To make kerosene oil effectual in removing scale from the inside of a boiler, from a feed water heater, or other place where scale has accumulated, it should be applied in liberal doses and at a time when the boiler, heater, or other device is comparatively cold. In using kerosene oil for removing old scale from a boiler, it must be used with some judgment, else the loosened scale will gather on the fire sheet, or between the tubes, and injurious effects may result. When the scaled boiler is open and dry the kerosene oil may be applied to the extent of a gallon or so to the lower rows of tubes, using a syringe for the purpose. If the scale is thick and porous it will readily absorb the oil; if the scale is dense and close grained more time should be allowed for the oil to penetrate. After a sufficient quantity of the oil has been introduced the boiler should be closed up, filled and run for about a week, then opened and the loose scale cleaned out. Another application of oil should then be made and the same process gone through with. This method will effectually clean the scale from a boiler in the course of a very few weeks.

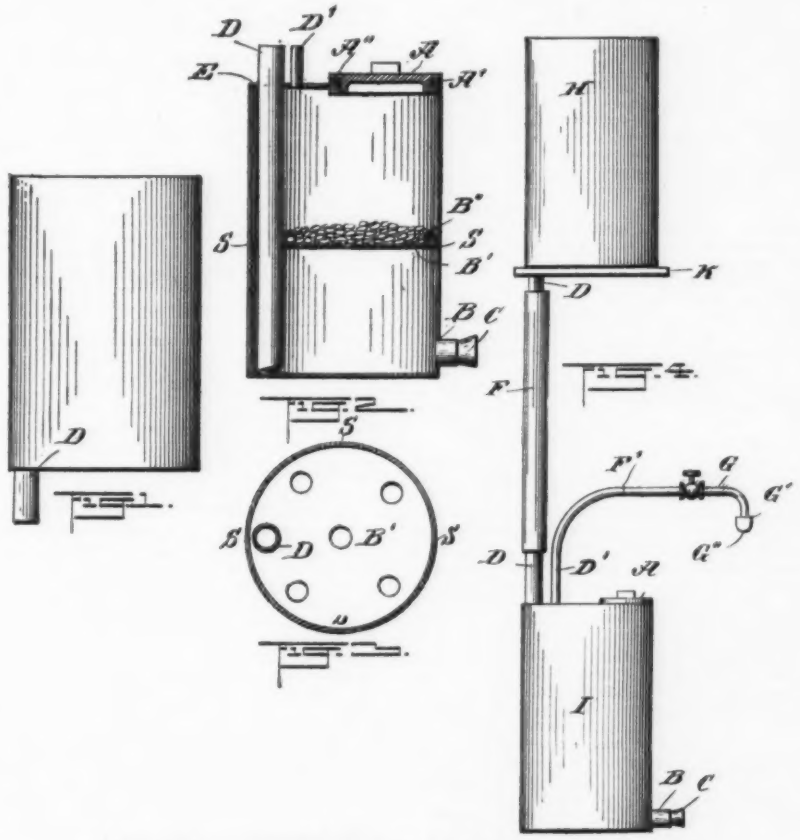
Another way of applying the oil has been used to good advantage. When the boiler is empty put into it about a bucketful of kerosene oil, then let the boiler fill very slowly. The oil will float on top of the water and be absorbed by the scale as they come in contact, until all the oil is absorbed. In this way the oil can be applied in greatest quantity to the scale which is nearest to the bottom of the boiler. A few such applications will effectually loose all the scale. Kerosene oil acts for this purpose, by reason of its penetrative power, working through the scale until it comes in contact with the iron, thus overcoming the adhesion between the scale and metal. When heat is applied to the boiler the oil soon begins to evaporate, and by its expansive force further loosens the scale and forms cracks in it, through which the water enters until it reaches the metal, after which the force of the steam further assists in breaking up and removing the scale, which will fall off in chunks, leaving the tubes and shell metallically clean where the breaking up process has taken place.

An absolutely clean surface inside of a boiler is not desirable. A thin incrustation not thicker than an egg shell, near the firing, is not injurious. It is frequently of benefit even, as it protects the boiler shell and tubes from the influence of injurious components of the feed water. But after all has been said as to the merits of the various boiler scale solvents as preventers, the only sure, satisfactory and rational course to pursue is to have the feed water analyzed and a physic made to suit its requirements. Any and all solvents—with the exception of kerosene oil—should be introduced gradually and continuously with the feed water. Usually, all that takes place when a compound is doing what it is supposed to do, is that the scale or deposit is rendered soft and comparatively easy to remove. The boiler requires regular cleaning and scaling just as if no compound were used. This is not always done, however, for it is thought by some that when a compound is used all the work on the part of the engineer or fireman in removing the scale and keeping the boiler clean is being amply accomplished by the compound.—American Manufacturer.

HOW TO MAKE AND USE LEAD-BURNING APPARATUS.

THE art of lead-burning, or of fusing two lead surfaces together by the oxy-hydrogen jet, is very much in use at the present time for connecting the cells of storage batteries in electrical vehicles. Although these joints may be soldered, the acid deteriorates the solder, and a satisfactory joint can only be made by lead-burning the straps together. It is the object of this article to describe how a simple lead-burner can be made and used by an amateur electrician.

The apparatus consists of two tanks which are made of lead, and, in order that they may be constructed with the least trouble, we have designed them to be made cylindrical in shape. Fig. 1 shows



PORTABLE HYDROGEN GAS LEAD-BURNING APPARATUS.

the upper, or pressure tank which is placed above the generating tank, and connected with it by a lead pipe. For a substantial and easily portable apparatus, these two tanks (*H* and *I*, Fig. 4) should be set in a suitable frame, the one above the other, and be rigidly connected by a lead pipe. But in order to make the apparatus still more simple, the upper tank can be placed upon a shelf and be connected with the lower one by a pure rubber pipe. This arrangement will probably be found satisfactory if the lead burner is not in continuous use for long periods of time.

The upper or pressure tank shown in Fig. 1 is open at the top and has a 1-inch pipe, *D*, leading from the bottom to the top of the generating tank. This upper tank is made of 8 pounds-to-the-square-foot sheet-lead. Its bottom can be soldered in place, and all other joints can be soldered, if the apparatus is only to be used intermittently.

Fig. 2 indicates the lower or generating tank, which should be made of 10 pounds-to-the-square-foot sheet-lead. A plumber's brass trap plug, *A*, is screwed into a collar, *A'*, which is soldered into the top of the lead tank. *A''* is a rubber gasket for making a tight joint. *B* is an outlet pipe 1 inch in diameter and half an inch above the bottom of the tank. It is closed ordinarily by the rubber stopper, *C*. *B'*, Figs. 2 and 3, is a perforated dividing sheet of 12-pounds-to-the-square-foot lead, which is soldered into the tank in at least four places, as at *S S S S*, Fig. 3. This sheet of lead should have at least five three-quarter-inch perforations to allow for a free circulation of acid. It is shown covered with bits of zinc which are introduced through the hole in the top of the tank, before the apparatus is set in operation. The lead-pipe, *D*, if a rubber connecting pipe is to be used, should extend about 2 inches above the top of the tank, and be tightly soldered in place at *E*. It passes down through the zinc carrier and is beveled on the bottom so as to keep it from resting flat on the latter and shutting off the circulation of acid, which would cause an accumulation of gas and would burst the generating tank. *D'* is a one-quarter-inch outlet pipe for the gas and is soldered in the top of the tank, as shown.

Fig. 4 shows the generator assembled for use. It should be charged in the following manner: After seeing that the rubber stopper, *C*, is in place in the outlet pipe, *B*, the plug, *A*, should be removed and 10 or 15 pounds of zinc should be placed upon the zinc-carrying partition, *B'*. The cap, *A*, should then be tightly screwed down, and the top tank of the generator should be filled with a solution of sulphuric acid and water in the proportion of 1 part of acid to 5 parts of water by volume. (Care should be taken to always pour the acid into the water, as otherwise an injury might be done to the operator.) The acid and water may be mixed in the tank, but it is preferable to mix them in an earthenware vessel. There should be enough solution to fill the upper tank about two-thirds full.

As soon as the acid reaches the zinc, gas will be generated and the solution will rise in the connecting tube and upper tank. The valve on the rubber flame-pipe, *G*, should then be opened and the air allowed to escape. If it does not escape fast enough, the rubber pipe can be removed from the gas outlet pipe, *D'*, for a moment and then be quickly replaced. Care should be taken, however, to see that no flame or light is in the neighborhood of the generator when this is done. As soon as the gas begins to issue from the jet, *G'*, it can be lighted by holding the jet near a candle. It will soon blow out with sufficient force to quickly melt the lead when held near it. The hole, *G''*, in the tip, *G'*, should not be larger than .012 to .015 inch, as a hole any larger will allow too much gas to escape, thus making too hot a flame and melting the lead too fast. If the flame proves too hot as it is, the escape of gas can be regulated more or less by the stop-cock in the rubber pipe, *G*. The art of melting the lead together properly has to be learned by experience. The tip of the jet should be held about an inch from the lead and the jet should be directed upon both surfaces as nearly as possible at the same time, so that they will both fuse at the same instant and run together. The surfaces should be scraped perfectly clean before attempting to fuse them, and it will be necessary to repeat this scraping at different stages of the operation, in order to remove the oxide that rapidly forms on the surface. With a little practice, almost any one can attain a certain degree of skill in lead-burning, but when attempting to learn the art, the operator must remember the above-mentioned points and also that the heat must be applied momentarily only, after the lead first shows signs of fusing. If the jet is kept on any length of time after the lead reaches this state, it will not only run together but will run out on all sides in a liquid stream, and cannot be confined to the places where it is needed.

In order to remove the charge from the generator after the operator is through using it, he should first remove the rubber tube, *F'*, from the gas outlet pipe, *D'*, so as to allow all the gas to escape from the generator. The rubber stopper, *C*, should then be withdrawn from the pipe, *B*, and the solution allowed to run into an earthenware vessel. After the charge of acid solution has thus been removed, replace the stopper, *C*, and fill the tank with water, allowing it to remain there for several minutes, after which it may be let out. The tank can then be left indefinitely until wanted for use again. To recharge the lead-burner, proceed as before. If the gas does not generate freely, a new charge of zinc should be put in. The acid

can be used a second time if a little fresh acid is added to the solution, but it is generally better to have an entirely fresh acid solution each time, if possible.

HEKTOGRAPH PAD AND INKS.

THE "pad," known as a hektograph, used in duplicating letters, is essentially a mixture of glue (gelatin) and glycerin. This mixture has the property of remaining soft yet firm for a long time and of absorbing and holding certain coloring matters in such a way as to give them up slowly or in layers, so to speak, on pressure.

Such a pad may be made by melting together 1 part of glue, 2 of water and 4 of glycerin (all by weight, of course), evaporating some of the water and tempering the mixture with more glue or glycerin if the season or climate require. The mass when of proper consistency, which can be ascertained by cooling a small portion, is poured into a shallow pan and allowed to set. Clean glue must be used or the mixture strained; and air bubbles should be removed by skimming the surface with a piece of card board or similar appliance.

The writing to be copied by means of the hektograph is done on good paper with an anilin ink. Formulas for suitable ones are appended. The purple ink is most frequently used, we think; it is said that more copies can be obtained from writing done with it than with other kinds:

Purple.

Methyl violet	2 parts
Alcohol	2 parts
Sugar	1 part
Glycerin	4 parts
Water	24 parts

Dissolve the violet in the alcohol mixed with the glycerin; dissolve the sugar in the water; mix both solutions.

Black

Methyl violet	10 parts
Nigrosin	20 parts
Glycerin	30 parts
Gum arabic	5 parts
Alcohol	60 parts

Blue.

Resorcin blue M	10 parts
Dilute acetic acid	1 part
Water	85 parts
Glycerin	4 parts
Alcohol	10 parts

Dissolve by the aid of heat.

Red.

Fuchsin	10 parts
Alcohol	10 parts
Glycerin	10 parts
Water	50 parts

Green.

Anilin green, water soluble	15 parts
Glycerin	10 parts
Water	50 parts
Alcohol	10 parts

The writing is allowed to dry without blotting. The pad having been moistened with clean water, the paper is placed on it, face inward, of course, and rubbed gently but firmly over every portion, care being taken to prevent its changing position. It is allowed to remain on the pad for from two to five minutes, and is then carefully removed. Copies are now taken by pressing dry paper on this surface and removing immediately. The operation should be carried out with as little interruption as possible. The New Idea states that the distinctness and sharpness of hektograph prints may be very materially heightened by wetting the paper upon which the prints are to be made with alcohol and removing the excess of alcohol by blotting paper.

After using the pad the ink should be removed from the surface immediately with a soft sponge and warm water, drying it well. It will then be ready for another operation. It may be used a great many times, if properly manipulated.—Drug. Circ. and Chemical Gazette.

ARE THE TRUSTS OVERCAPITALIZED?*

WITH a perseverance worthy a great cause, some analytical minds persist in following up the vast consolidations, amalgamations and admitted trusts which darken the commercial sky, putting inconvenient questions, drawing undesirable deductions, and revelling in uncomfortable anticipations. One university professor asserts that the United States Steel colossus is in imminent danger of insolvency on account of prodigious overcapitalization.

It is well known that in many cases no dividends on common stock are ever paid, which in frequent instances has been issued to the promoters simply to enable them to unload and get their money from a confiding public. In this connection, the following extract from the Report of the United States Commissioners may be found of interest:

In many cases, at least, the nominal capitalization far exceeds the cash value of the property. Some of the witnesses are of opinion that the question of capitalization is of slight consequence. They think that if the amount of stock issued is only three or four times in par value more than the cash value of the plants themselves, no especial harm is done.

If the earning capacity is sufficient to pay dividends on the large capitalization, the stock will hold its value fairly well, and the capitalization is justified. If the earning capacity is not sufficient to pay dividends, this condition will show itself in the value of stocks. While some individuals may be injured by the purchase of stocks through misrepresentation, that is not a matter that concerns materially the general public. People who deal in stocks are likely at times to lose. The State, it is said, cannot act as guardian for foolish individuals. It is not believed by those witnesses that overcapitalization has any effect upon prices which is injurious to the public.

None of the witnesses believe that the Standard Oil Company is on the whole overcapitalized, as compared with the present value of the plants.

The American Sugar Refining Company seems to be, beyond question, capitalized at a sum twice as large at least as the cost of reconstruction of the plants themselves. The capitalization was shown to be several times the original capitalization of its constituent members.

The Distillers and Cattle Feeders Trust was capitalized at an amount far beyond the cash value of its plants. Mr. C—— asserted that he was paid in trust certificates four times the agreed upon fair cash value of his plant.

Regarding the Tin-Plate Combination, the owners of most of the plants gave an option on their plants at what they considered was the fair cash value. They were then given, by the promoter, the option of taking this valuation of their property in cash, or of taking instead the same amount of preferred stock, with a like amount of common stock added as bonus. The price of the stock on the market shows that the common and preferred together have so far ranged above the cash valuation.

One of the witnesses, at least, conceded that the total amount of stock thus paid for the plants probably amounted in some instances to three or four, or even five times the cash cost of the plants at that time.

In the capitalization of the National Biscuit Company, the National Steel Company and the American Steel Hoop Company, there was a clear understanding that the common stock represented simply bonus or anticipated profits. The cash options taken on the plants included also in the minds of the sellers the goodwill, presumably as a fairly high price, considering the prosperous times and the added advantage which was expected to be obtained from the combination itself. In the case of the American Tin-Plate Company there was also added ten millions of common stock, which was issued to the promoter for his services and for the cost of organization. It is presumed of course, that not a little of this ten millions had to be paid out in commissions, etc., to those who aided in securing the required amount of capital, including cash furnished for working capital. The amount of extra common stock issued for the purposes of promotion in the American Steel Hoop Company and in the National Steel Company was $5,000,000 in each case.

One of the chief causes of this overcapitalization springs from the high profits that are secured by the promoters and by the underwriters of the stock when the combinations are made. According to the testimony of Mr. Clarke, when the Standard Distillery and Distributing Company was organized, for each $100,000 of cash advanced to buy the plants, the underwriters received $100,000 in preferred stock and $150,000 in common stock.

In cases that are considered fairly conservative the amount of stock issued, including both preferred and common stock, is from two to three times more than their value, while in not a few instances—for example, the one cited by Mr. D——, where value of possibly $500,000 was capitalized for $8,000,000—the capital stock seems to bear little relation to actual value of plants and patents.

* The Book-Keeper.

THE CHEMISTRY OF PRODUCER GAS.

IT has long been known that at certain temperatures carbonic acid gas in contact with carbon is unstable, and taking up an additional atom of carbon, becomes carbon monoxide, says Engineering. It is less generally known that the latter gas is also unstable under certain conditions, reverting to CO_2 with deposition of carbon. These cases of dissociation and combination have recently been carefully studied by M. O. Boudouard, who, in a recent issue of the Bulletin of the Paris Chemical Society, discusses the bearing of his researches on the metallurgical industries. He has ascertained in what proportions the two gases form stable mixtures at different temperatures when in contact with fuel, and claims that a comparison of his results with analyses of producer gas will, in any case, give useful information as to the working of the apparatus. His results show the maximum proportion of carbon monoxide which can be obtained with a producer working at a given temperature. These maximum results are in practice never attained. The ideal producer should yield merely CO and N in the proportion of 24.3 volumes of CO to 65.6 of N. Owing to dissociation of the CO_2 the gas in practice always contains CO_2, and in greater proportion as the working temperature is lower. In fact, the conditions of working can be so arranged that the whole of the carbon is obtained as CO_2. For instance, a high velocity of the air through the furnace is favorable to the production of CO_2, since insufficient time is given for its reduction, after formation, to CO by taking up more carbon. A porous and finely divided fuel, on the other hand, promotes a good yield of CO, as does also a high temperature of working. In laboratory experiments it was found that in passing CO_2 over carbon at the temperatures noted below, the following proportions of CO were obtained:

Deg. Cent.	Per cent of CO.
600	23
700	58
800	93
900	96.5
1,000	99.3

Thus, at one thousand degrees the CO_2 is practically completely broken up, but producers never work at so high a temperature, and hence always give a certain proportion of CO_2. In actual practice the gases are, of course, largely diluted with nitrogen, which makes a longer time necessary for the establishment of equilibrium. Similarly, the kind of fuel used is of importance. Equilibrium is established pretty quickly when wood carbon is used, but with coke and above all bone carbon, the stable state is not reached after several hours' heating at 800 deg. C. Summing up, to get a good yield from the producer, the air current through the furnace should be slow, the temperature high, and the combustible porous and finely divided. In blast furnaces the carbon monoxide is formed in the hottest part of the furnace near the tuyeres, since here the temperature is too great for CO_2 to exist. This CO_2 proceeding upward through the furnace, picks up oxygen from the ore, forming CO_2, and then, meeting with glowing carbon, is again partially reduced to CO. If the quantity of this latter gas produced in the neighborhood of the tuyeres is already sufficient to reduce the ore, this second production of CO constitutes a useless loss of heat. Hence, within limits, the loss of heat through the comparatively thin walls of the upper portion of the furnace may be made up for by the lessened production of CO in this portion of the furnace, following the reduction of the temperature consequent on the loss of heat. Again, the less the time the CO_2 is in contact with the hot fuel the less the carbon monoxide formed; hence high-air pressures should be used with high furnaces, though too great a rate of flow of the air may prevent the proper reduction of the ore. The fuel should also be in as large pieces as possible, so as to expose a small surface of the carbon dioxide.

TRADE NOTES AND RECIPES.

White Ink for Use on Colored or Black Paper.—Rub up with thin mucilage of gum arabic, either zinc white, calcined ammonia, alum, flake white or any similar impalpable powder. When you have the whole well incorporated, dilute with very weak mucilage or water, until you get a fluid that flows easily from the pen. The addition of a little ultramarine improves the color, which is otherwise inclined to be yellowish.—National Druggist.

To Mend Meerschaum.—If the material is genuine (natural) meerschaum a lasting joint can be made between the parts by proceeding as follows: Clean a clove or two of garlic (the fresher the better) by removing all the outside hull or skin; throw into a little mortar, and mash to a paste. Rub this paste over each surface to be united and join quickly. Bring the parts as closely together as possible and fasten in this position. Have ready some boiling fresh milk; place the article in it and continue the boiling for 30 minutes. Remove and let cool slowly. If properly done, this makes a joint that will stand any ordinary treatment, and is nearly invisible. If of composition, use a cement made of quicklime, rubbed to a thick cream with egg albumen.—National Druggist.

Special Gloss Dressing for Harnesses.—The Seifensieder Zeitung, Augsburg, gives the following recipe for the production of special gloss dressing for harness leather:

Ox blood, fresh and well purified	10 kilos
Glycerin, technical	2 kilos
Turpentine oil	3 kilos
Pine oil	5 kilos
Ox gall	2 kilos
Formalin	150 grammes

The raw materials are stirred together cold in the order named. Pour the mixture through thin linen. It imparts a wonderful, mild, permanent gloss.

Durable Surface for Cafe Tables, Bars, etc.—To provide tables, etc., in saloons, which are exposed to beer, wine and liquors with a resistive polish, the Wiener Moebelhalle gives the following directions:

Dissolve

Sandarac	200 grammes
Gallipot	50 grammes
Gum benzoin, finely powdered	15 grammes
Camphor	15 grammes

in 600 grammes of 95 per cent alcohol; place the bottle in a warm spot and shake from time to time. Next, pour the liquid through a clean cloth into another bottle, add 25 grammes of sulphuric ether and cork up the bottle well. Polish in the usual way, but not by artificial light, as the ether ignites very easily.

Baking Powder.—A formula for this powder proposed by Crampton, of the United States Department of Agriculture, as the result of an investigation of the leading baking powders of the market, is:

Potassium bitartrate	2 parts
Sodium bicarbonate	1 part
Corn starch	1 part

The addition of the starch answers the double purpose of a "filler" to increase the weight of the powder and as a preservative. A mixture of the chemicals alone does not keep well.

The stability of the preparation is increased by drying each ingredient separately by exposure to a gentle heat, mixing at once, and immediately placing in bottles or cans and excluding excess of air and consequently of moisture.

This is not a cheap powder; but we cannot recommend any substitute. It is the best powder that can be made, as to healthfulness; there are others which while cheaper are strongly, and we are convinced, justly, opposed by sanitarians.

Removal of Paint from Clothing.—Before paint becomes "dry" it can be removed from cloth by the liberal application of turpentine or benzine. If the spot is not large, it may be immersed in the liquid; otherwise a thick, folded absorbent cloth should be placed under the fabric which has been spotted and the liquid sponged on freely enough that it may soak through, carrying the greasy matter with it. Some skill in manipulation is requisite to avoid simply spreading the stain and leaving a "ring" to show how far it has extended.

When benzine is used the operator must be careful to apply it only in the absence of light or fire on account of the extremely inflammable character of the vapor.

Varnish stains when fresh are treated in the same way, but the action of the solvent may possibly not be so complete on account of the gum-resins present.

When either paint or varnish has dried, its removal becomes more difficult. In such case soaking in strong ammonia water may answer. An emulsion formed by shaking together 2 parts of ammonia water and 1 of spirits of turpentine has been recommended as useful for the purpose in view.—Drug. Circ. and Chem. Gaz.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

American Shoe Stores in Germany.—The sale of American-made shoes in Germany, which was begun on a small scale about 1896 by a few enterprising retailers and increased steadily by reason of the superior style and durability of the goods, has received during the past year a powerful impetus through the immediate and extraordinary success of a large, handsome, typical American shoe store which was opened in Berlin early in April, 1901. The enterprise has proven so profitable that the same management has opened a similar establishment in Frankfort, and is preparing to open another at Hamburg in September. This prompt and noteworthy success has been due to the fact that, in addition to the merits of the shoes offered, the manager—Mr. Barthmann—began in the right way by opening an exclusively American shoe store, so spacious, handsome, and characteristic in its appointments as to form an attraction on one of the most thronged streets of Berlin. Not only the entire stock of shoes, but the fixtures and the show windows, the shelving, and the whole method of conducting the business, are typically American. The goods offered represent the product of two leading American manufacturers, one of whom makes men's shoes of every kind, the other shoes in large variety for women, and every pair of shoes in the store is retailed at the uniform price of 18 marks (equal to $4.28 in United States currency).

Prior to the opening of this real American store, shoes of American manufacture had been sold in Germany at prices about equal to those of the higher grades of native custom-made foot wear. The $3 and $3.50 shoe from Lynn or Newark or Brockton was treated as a luxury by the German dealer and retailed at from 24 to 28 marks ($5.11 to $6.66) per pair, prices which put them beyond the reach of all but the well-to-do class of purchasers. The effect of the enterprise above cited has been to reduce by from $2 to $2.50 the cost of a pair of good American shoes in Berlin. The number of persons who will pay extra prices for the name of a shop or for something slightly better than the standard article is relatively small. The German, as a rule, is a careful buyer, and it is the salesman who can sell a foreign-made article superior in value to the home product, at a slightly advanced or equal price, who will capture the valuable trade of the German middle class. Not only will the sale of American shoes be promoted in Germany by the lower prices that are likely to be introduced by the establishment of American shoe stores, but these stores will be able to handle the trade better than has been done before.

The German retailers selling American shoes have, as a rule, carried a very limited stock, which, owing to the difficulties of obtaining regular and prompt supplies from American manufacturers, were constantly becoming exhausted in certain sizes and forms, the result being that the German salesman frequently tried to sell shoes that were too large or too small or were of German make. Many shoes are made in Germany with American machinery from American models, and it is perhaps only very natural that they should be sometimes sold as American goods to the uninitiated, when there are no genuine American shoes of the correct size at hand. Examples are known where American shoes were prominently shown in the windows, were asked for by American purchasers, and yet shoes made in Germany according to American styles were sold in the place of the American article. It is really surprising and a conclusive proof of the intrinsic value of the American shoe that, in spite of the commercial disadvantages with which they have had to contend, their sale has shown a steady and substantial growth.

As to the success of the first typical American shoe store, there can be no question. The sales room is generally crowded at all times of the day. The sales book of the establishment during a recent month showed sales running from $400 to $1000 per day, the lowest day's sale being slightly over $400. Judging from the thronged sales room and the class of customers now attracted, it is apparent that the trade is securely established and increasing.

A German doctor—a personal friend—called my attention to his shoes bought at the American shoe store; and in explaining the reason for his preference, he said that he formerly had to go several times to have his shoes tried on by the shoemaker, wait a couple of weeks, and then the shoes were not always what he wanted. He now goes to the American store, takes two minutes, and is supplied with shoes that are satisfactory in every respect. There is but little doubt as to where the good doctor will go in future. The duty on a pair of shoes coming into Germany is at present from 10 to 15 cents, according to weight, and after deducting charges for freight and duty, there remains undoubtedly a generous profit over the amount paid by the retailer on the shoes which he sells at 18 marks ($4.28). While Berlin is undoubtedly the most favorable place for such an experiment, there seems good reason to believe that similar enterprises in other German cities will meet with corresponding success on a smaller scale. If it be worth while to establish an American shoe store in Frankfort, there would seem to be no apparent reason why stores established at Dresden, Munich, and other cities of approximately the same size should not prove lucrative. There are two possible barriers in the way of the development of the American shoe trade in Germany—an increase in the tariff and the improvement of German shoes, owing to the introduction of American machinery and methods.

According to the proposed revision of the tariff at present under discussion before a committee of the Reichstag, the duty on imported shoes will be from 80 to 120 marks per 100 kilogrammes ($19.04 to $28.56 per 220.46 pounds). As to the competition of shoes made by American machinery in Germany, it has existed during the past six or seven years; and, notwithstand this fact, there is a radical difference in the quality of these shoes, as compared with the American article. There may come a time when German shoes will equal those of American make, but they have not yet succeeded in rivaling the elegance and durability of the better grade of American shoes. Of course, business ability and an adequate capital are always necessary in the founding of any new business, and the manager of any such enterprise should have a practical knowledge of the shoe business and know something about Germany and the German language. The same opportunity which has been taken advantage of by the shoe store at Berlin has existed for years, as the difference between the quality of the American machine-made shoes and those made in this country was greater five or ten years ago than at present. A large and valuable trade has been lost in the past by the slowness of American business men in recognizing their opportunity in this country. It is to be hoped that in the near future this trade will be systematically and energetically pushed. There would certainly seem to be room for a large wholesale house which would be in a position to supply German retailers with the different sizes and qualities of shoes, as the purchase of shoes in America by German retailers is attended with many inevitable delays and vexations.—Dean B. Mason, Vice and Deputy Consul-General at Berlin.

American Lumber in Rotterdam.—Having lately had some inquiries as to the current prices of American lumber at Rotterdam, I have investigated the matter and find that the following quotations rule at present for logs per 1000 feet Scribner rule and for lumber per 1000 feet board measure:

Prime walnut logs, 16 inches and upward:	
To average 21 to 22 inches	$90.00 to $100.00
To average 23 to 24 inches	110.00 to 120.00
Prime white-oak logs, 24 inches and upward	42.00 to 44.00
Whitewood logs, 28 inches and upward	42.00 to 44.00
Prime hickory logs, with small, brown heart	52.00 to 54.00
White-ash logs, 14 inches and upward	44.00 to 45.00
Gum boards and planks, 1 to 3 inches thick	42.00 to 46.00
White-oak boards and planks, 1 to 3 inches	46.00 to 51.00
Oak scantlings, 3 by 3, 4 by 4 inches, 8 to 16 feet	40.00 to 42.00
Cottonwood boards and planks, 1 to 3 inches	28.00 to 31.00
Walnut boards and planks, 1 to 4 inches	105.00 to 125.00
White-oak stairsteps, 1¾ or 2¼ inches by 11, 12, or 13 inches	52.00
White-oak parquetry strips:	
1 by 4, 4½, 5 to 6 by 20 or 24 inches.	38.00
1 or 1¼ by 4 to 6 inches, 10 to 16 feet long	43.00 to 44.00
White-ash boards and planks, 1 to 3 inches	44.00 to 48.00
Pitch pine, 1 to 3 inches by 11 inches and upward, per standard	63.25 to 65.68

Messrs. J. C. & Th. H. Leyenaar, one of the leading firms that handle American lumber at this port, has, at my request, furnished me with its views as to the prospects for the American lumber trade here this season:

"The Netherlands buy, as a rule, with the exception of pitch pine, very little lumber from America, but a good many logs. The sale of the latter is fair and the business prospect is not unfavorable.

"Germany (which country is supplied from this port to a great extent) buys more lumber than logs. Conditions there have not as yet improved much since last year. Though money has become cheaper, the trade continues dull, and prospects are not very bright for any great revival of the lumber trade."—S. Listoe, Consul at Rotterdam.

American Dried Fruit in Switzerland.—At the request of a San Francisco firm,* I have investigated the subject of the importation of dried fruit into Switzerland, and I give below part of a letter addressed to me by Mr. Feller-Villiger, of Zurich, one of the largest dealers in this article in Switzerland:

"The import of American dried fruit is always profitable for the seller, for the reason that no other country produces the finer kinds of dried fruit, which have for the last fifteen years been imported into Switzerland and always find a ready sale in this country, no matter whether the home crops are good or bad.

"The kinds bought from the United States are principally the so-called apple rings and apricots; then follow pear chips, prunes, and peaches. The first two kinds are imported in very large quantities, unless the prices are exceptionally high.

"Other countries (Germany and Bohemia) furnish the ordinary dried pears and Turkey and Servia send plums. These kinds of dried fruit have never been offered to me for sale from the United States; in fact, I have never known of their coming from that country. These articles are consumed in enormous quantities and are very cheap, especially when the crops are good, and I do not believe that the United States could enter into competition.

"The duty is favorable to the import of dried fruit; for apricots, apples, peaches, and pear chips (that is, for all kinds without stones), 15 francs per 100 kilogrammes ($2.89 per 220 pounds), and for stone fruit only 2.50 francs per 100 kilogrammes (48 cents per 220 pounds) are charged. As long as we retain this tariff, American dried fruit will maintain its prominent position on the Swiss market."

In view of the fact that the late frost has done great damage to the fruit trees all over Europe, I believe that the prospect is good for a largely increased import of all kinds of fruits and nuts from the United States, notwithstanding the fact that the new tariff now under consideration by the Swiss government† provides for a considerable increase in the duties on these articles.—Henry H. Morgan, Consul at Aarau.

The Coffee Crop of Guatemala.—The recent earthquakes, which totally destroyed Quezaltenango, the second city of Guatemala, and many of the neighboring smaller communities, visited with awful consequences the prosperous coffee plantations of the Republic. While the coffee trees themselves suffered little damage, the dwellings, storehouses, electric installations, coffee machinery, and other improvements on nearly all the estates were more or less seriously injured; and this will necessarily divert attention from the gathering of the coffee crop to the early repairing of the almost universal damage. Before the catastrophe of April 18, indications pointed to a very large output of coffee next season, but I can now say that the yield will not be one-half what was expected.

Many things at this time combine to retard even the necessary repairs on the estates. The most serious difficulty is the lack of labor. For many seasons past, the impossibility of securing adequate help for cleaning the coffee trees has been a source of constant loss to most of the coffee planters, and now that the surplus labor of the Republic has been pressed into service to clear away the débris in the ruined cities and towns, the question has become still more serious. The building of new railway lines has also induced many laborers to leave the coffee estates to engage in grading or track laying. To escape compulsory service in the ruined cities, it is said that many laborers are crossing over into Salvador or Mexico.—James C. McNally, Consul-General at Guatemala City.

Projected Improvements in the Harbor of Genoa.—I have obtained, through the courtesy of Signor Inglese, chief of civil engineers, the plans and estimates for the improvement of the port of Genoa, which have been approved by the Minister of Public Works at Rome. It is understood that bids for the entire project will soon be invited.

An American contractor, backed by ample capital, is now on the ground, and offers to do the entire work within less than the estimated time.

In support of these plans, Signor Inglese has submitted a very elaborate report to the Italian government, from which I gather the following information, which may be of interest not only to contractors in the United States, but to those engaged in foreign commerce.

The commercial movement of the port of Genoa, which amounted in 1870 to 1,000,000 tons of merchandise loaded and discharged, at the end of the year 1900 had reached a total of 5,300,000 tons, and yielded from customs duties and port charges a revenue to the national treasury of about 90,000,000 lire ($17,370,000).

In 1880, there was a sudden increase in the commercial activity at Genoa, as the benefit of the Galliera legacy began at that time to make itself felt. The Duke of Galliera had bequeathed some $4,000,000 for the improvement of the harbor of Genoa, and the results of this expenditure were shown at once in increased traffic and prosperity for the city.

Estimates have been made of the increase of traffic to be expected in the future; but as the aggregate tonnage anticipated for 1903 had already been reached in 1898 and as the total for 1905 was surpassed in 1900, the engineer who had planned the new works has based his statements upon conditions reasonably to be anticipated for the year 1910.

In this calculation, due weight has been given to the commercial effect of the opening of a new artery of trade under the Alps by way of the Simplon route, which will be completed in 1905. Of the business of the port of Genoa, only 30 per cent is local or provincial, while 70 per cent is international or interprovincial.

The principal works proposed are:

1. A new anchorage basin of 39 hectares (about 80 acres), which will nearly double the present available water surface, and is designed especially for the discharging of coal. On this point, the engineer remarks, significantly: "We should bear in mind that from now on, the importation of American coal into Europe is an assured fact."
2. The construction of a sea wall.
3. Increased trackage along wharfs for railway traffic.

The accompanying diagrams* indicate the scope and character of the completed works.—Richmond Pearson, Consul at Genoa.

American Shoes in Bohemia.—The first stock of American shoes ever placed on sale in this locality was recently received at a store in this city, and the columns of the local papers were freely used in announcing the important fact. A few days thereafter, on taking to the store an American friend who needed a pair of shoes, I was told that the entire stock had not only been sold, but that (translating into equivalent English) it "went off like hot cakes." Another stock has been ordered and is daily expected.

No overt opposition to the invasion of the American shoe has appeared in this locality, and the purchasing public has eagerly welcomed it.—Frank W. Mahin, Consul at Reichenberg.

* Filed in the Bureau of Foreign Commerce, where they may be examined by parties interested.

* Advance Sheets have been sent the firm.

† See Advance Sheets Nos. 1295 and 1309; Consular Reports Nos. 260 and 261.

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No. 1374, June 23.—*American Dried Fruit in Switzerland—*American Coal in Switzerland—Chemical Industry in Germany in 1901—The Sowings of Sugar Beets in Europe—Russian Regulations for Hemp Export—Conditions in German Iron Trade.

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No. 1379, June 28.—*Packing Apples for Great Britain—Iron Works in New South Wales—Lace and Hosiery at Nottingham—*Regulations Concerning American Shooks—Electric Plant in Amsterdam—*The Osaka Exhibition.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

SELECTED FORMULÆ.

Liquid Dressings for Russet Leather Shoes, etc.—The following are the "latest improved" dressings for russet leather footwear:

Yellow.

Borax in crystals	40 parts
Glycerin	20 parts
Ammonia	2 parts
Shellac, bleached	200 parts
Aniiin yellow (No. 690) water-soluble	6 parts
Formalin	1 part
Water	1,200 parts

Orange.

The same as the above, except that instead of 200 parts of bleached shellac, 180 parts of ruby shellac, and instead of yellow, 6.4 parts of orange R. and 2.4 parts of brown (No. 2925), water soluble, are used.

Light Brown.

The same as the first, with the exception of the color, instead of which use use 6.4 parts of yellow (690) and 2.4 parts of Orange R.

The following is the method of procedure: Bring the water to a boil, but just before it commences to do so withdraw a portion and in it dissolve the color or colors. To the residue add the borax, and a little later the shellac. As soon as the shellac is dissolved draw the fire, and after the solution cools down a little add the color solution and finally the gycerin and ammonia, which should be mixed prior to addition.—Nat. Drug.

Lanolin Cream.—

Anhydrous lanolin	650 grammes
Almond oil	200 grammes
Water	150 grammes
Oil of ylang-ylang	20 drops

—Drug. Circ.

Ink Eraser.—Make two solutions as follows:

Sol. A. Citric acid	1 part
Saturated solution of borax	2 parts
Distilled water	10 parts

Dissolve the acid in the water, add the borax solution and mix by agitation.

Sol. B. Calcium chloride	3 parts
Saturated borax solution	2 parts
Water	16 parts

Dissolve the chloride in the water, add the borax solution and mix.

To use: Go over the writing with a camel's-hair pencil dipped in solution A. Remove excess of moisture with a blotting pad, and subsequently apply solution B in the same manner. Use a clean pencil for each solution. The following is a very satisfactory preparation if properly made, and like the foregoing, consisted of two solutions:

Sol. A. Potassium chloride	1 part
Potassium hypochlorite	1 part
Water	3 parts

Mix and dissolve by the aid of heat.

Sol. B. Hydrochloric acid	1 part
Sodium chloride	1 part
Water	3 parts

Mix and dissolve.

To use: Go over the letters with solution A, using a delicate sable or camel's hair pencil in so doing, and avoiding spreading as much as possible. Let dry and go over with solution B, using a separate brush and the same precautions as before. This will remove almost any ink used in ordinary correspondence or recording. Like the first preparation, this may be used for removing spots from clothing.

In using any chemical eraser the part upon which the solutions are used should be moistened with clear water subsequently and dried with a blotter.—Nat. Drug.

Sulphur Cream for Dandruff.—

White wax	3½ drachms
Liquid petrolatum	2½ ounces
Rose water	1 ounce
Borax	15 grains
Precipitated sulphur	3½ drachms

—Drug. Circ.

Copying Ink for Making Several Copies.—

Extract of logwood	100 parts
Ammonium oxalate	30 parts
Aluminium sulphate	30 parts
Oxalic acid	8 parts
Potassium dichromate	1 part
Salicylic acid	1 part
Water, rain or distilled, sufficient.	

Reduce the first four ingredients to a coarse powder, mix, add 800 parts of water and boil together in a copper vessel. Dissolve the potassium dichromate in 150 parts of hot water and add to the boiling liquid. Add the salicylic acid, remove from the fire and set aside for 14 days. Decant the clear liquid and bottle. —National Druggist.

Narcissus Perfume.—

Caryophyllin	10 minims
Extract of tuberose	16 ounces
Extract of jasmin	4 ounces
Oil of neroli	20 minims
Oil of ylang-ylang	20 minims
Oil of clove	5 minims
Glycerin	30 minims

—Drug. Circ.

"**Bischoff.**"—We find in La Nature the following recipe for this famous and favorite pick-me-up:

Peel of green orange, fresh	120 parts
Peel of Curacao orange, ripe and fresh	360 parts
Ceylon canella	4 parts
Cloves	15 parts
Alcohol	3,600 parts
Good Hungarian wine	1,440 parts

Mix and let macerate together, until the drugs are exhausted; then decant, press off, and filter.—National Druggist.

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